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Emulation of the AN/UYK-20 tactical data computer on the Burroughs D-machine

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NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

EMULATION OF THE AN/UYK-20
TACTICAL DATA COMPUTER
ON THE BURROUGHS D-MACHINE

by

Ralph Harry Anzelmo
and
Theodore Lawrence Kaye

March 1977

Thesis Advisor: L. V. Rich

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Emulation of the AN/UYK-20 Tactical Data Computer on the Burroughs D-machine

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MARCH 1977

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I. INTRODUCTION

A. STATEMENT OF THE PROBLEM

The Navy has been challenged with maintaining the newest, most efficient tactical data systems consistent with the continually increasing demands and requirements of the real-time environment. There is an extensive conversion effort required to change from existing systems to newer more sophisticated technology such as the AN/UYK-20. Inherent in upgrading to a new system is the complex software redesign and modification process which is often hindered by the absence of the new computer system.

Unfortunately, the demands of a military installation require software generation prior to implementation of an upgraded computer system. One solution to this problem is to utilize for software development an intermediate computer system which has the capability of emulating the anticipated target machine. This provides a vehicle for software design, development, and testing prior to transitioning to the new system.

Currently, the Naval Postgraduate School (NPS) Computer Science Department maintains a Burroughs Interpreter-Based System known as the Burroughs D-machine. The D-machine is capable of being microprogrammed to emulate any of a miriad

of target machines. It effectively enables students to create their own computer knowing only the machine instruction repertoire for the control unit in the target machine.

The problem presented was to develop a feasible working model of the AN/UYK-20 on the microprogrammable Burroughs D-machine. The project provided an opportunity to obtain practical experience with contemporary hardware and to manipulate writeable control stores to imitate a Navy tactical computer.

B. APPLICATIONS OF THE AN/UYK-20

The Univac AN/UYK-20 minicomputer is a general purpose militarized digital computer adaptable to numerous tactical applications. The AN/UYK-20 has been successfully utilized in many time-critical, real-time systems including fire control radar, communication controllers, signal processing analyzers for sonar and beacon signals, and numerous weapons control systems. A subsequent chapter will be devoted to the technical aspects and internal design of the AN/UYK-20.

Because of its size, ruggedness, and computing capabilities, the AN/UYK-20 has been designated the Navy's standard tactical minicomputer [16]. It was selected for emulation in order to provide a feasible platform for software development to those military installations either contemplating or in the process of receiving an AN/UYK-20.

A workable emulation would allow military applications such as data reduction, navigation, telemetry, sensor processing, range tracking and logistics to have software packages developed, tested, and modified prior to arrival of the AN/UYK-20. Furthermore, it would permit personnel to become familiar with the machine by providing advanced training, thereby easing the transition phase to the new system.

C. PROJECT DESIGN OBJECTIVES

Several design techniques were used throughout the development of this project: 1) modularity, 2) structured programming, and 3) extensive documentation. These design features will aid the interested reader as well as simplify any future extensions or modifications to the existing emulation.

Modular design was utilized by creating independent program segments which were individually developed, debugged, and tested. These modules or subroutines provided a strong foundation which were readily modified throughout the entire programming effort. Conceptually, the emulation was divided into relatively small entities which were further reduced to program segments rarely exceeding one page in length.

Structured programming was demonstrated by utilizing a limited number of control flow structures and maintaining a common logical design throughout the entire emulation. Comprehensible code held precedence over extremely efficient

code.

In addition to modularity and structured programming, the entire programming endeavor was supplemented with extensive commenting to provide the necessary self-documentation to promote and facilitate program translation, modification, and fusing with the other independent modules. These concepts promoted the extensive team effort required to achieve the research goals. In addition, it will provide ease of program maintenance and modification in the future.

II. EMULATION

A. HISTORICAL BACKGROUND

The term microprogramming was first utilized in an article by Professor M. V. Wilkes of the Cambridge University Mathematical Laboratory in 1951 [24]. His paper concentrated on a control section within the computer which, when programmatically controlled, performed register-to-register data transfers sequentially and in parallel for the execution of a single machine instruction. A sequence of operations (microinstructions) required for execution of a machine instruction is considered a microprogram.

Traditionally, the computer has been composed of essentially five components: the arithmetic/logic unit, the control unit, memory or storage, input, and output (Figure II-1). The control section sets the proper conditions for the opening and closing of required gates in the logic network. Historically, the control section has been hardware consisting of a series of decoders and flip-flops along with their associated circuitry. Therefore, every machine instruction had a fixed interpretation which was hardwired within the control unit.

In 1957, Wilke's definition of microprogramming was slightly modified. It was defined as a technique of design-

ing the control circuits of an electronic digital computer to interpret and execute a given set of machine operations as an equivalent set of micro-operations [15].

The hardwired control section can be modified by interchanging ROM modules or other hardware components, by replacing the control section with a programmable (dynamically writeable) control store which in itself is a separate word-organized memory (Figure II-2) or by combining both approaches. A programmable control store allows rapid changes in the machine's instruction repertoire while maintaining maximum design flexibility. The resulting computer system is microprogrammable and capable of storing a series of changeable machine personalities.

The computer control store can thus be modified to allow the execution of machine language programs intended for a variety of machine architectures. This process can be compared to replacing hardware components found in conventionally designed computer systems. The primary advantage of microprogrammed logic is the capability to perform various control sequences without hardware modifications. The process through which the hardware components of one machine (host) are made to imitate the specific hardware characteristics of another machine (target) is known as emulation.

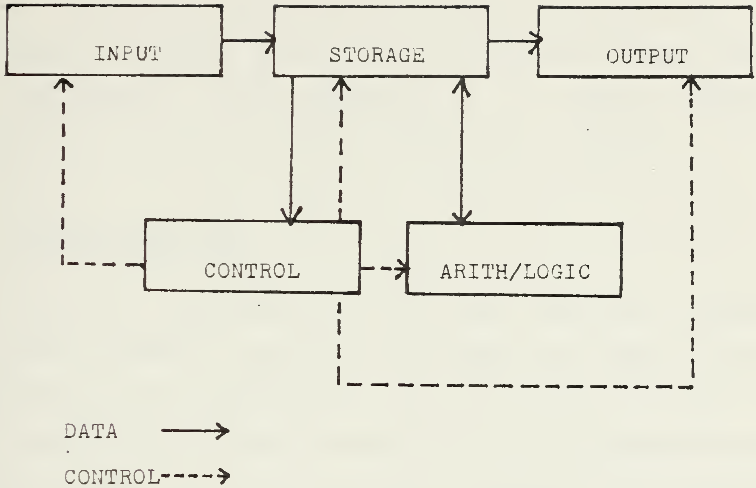


Figure II-1 [11]

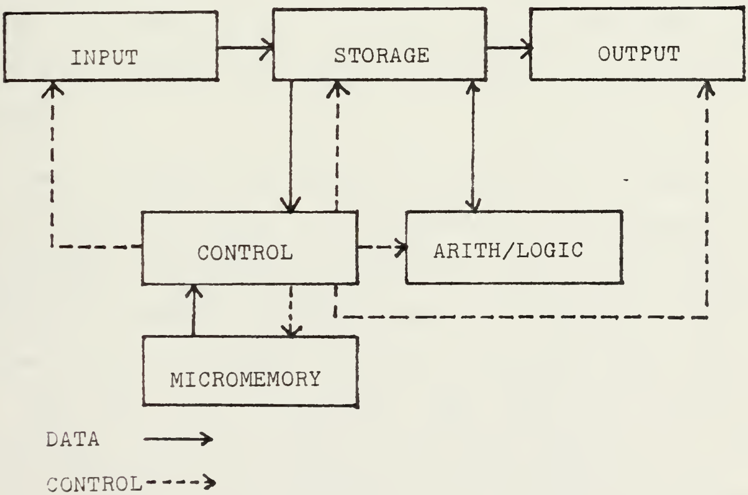


Figure II-2

Emulation allows the computer scientist to create various machine architectures from a single microprogrammable host. The complete set of microprograms (firmware) and the necessary hardware, as well as the required software, added to one computer system enabling it to execute programs designed for another system is known as an emulator.

B. MICROPROGRAMMING

Computer manufacturers have made available numerous microprogrammable machines which permit the user to tailor his instruction repertoire to meet the needs of his particular application. Some examples of microprogrammable computer systems are the Burroughs D-machine, the Nanodata QM-1, the Varian 73, the Standard Logic CASH-8, or the Hewlett-Packard 2100. These microprogrammable systems provide the benefits of flexibility, lower system costs and a systematic approach to system design if utilized effectively.

When a manufacturer designs a dynamically writeable control store, the amount of parallelism to be allowed must be determined. Parallelism is defined to be the simultaneous control of numerous hardware resources. There are basically three forms of control: vertical, horizontal, and residual. In vertical microprogramming, each instruction controls a single operation with program flow being sequential, unless the instruction was a conditional or unconditional branch. By contrast, a horizontally microprogrammed machine is

programmed via instructions which simultaneously control multiple resources including condition testing and microinstruction sequencing.

Horizontal microinstructions usually are not encoded which means each bit controls one machine resource or operation. They usually have a wider word than vertical instructions and consequently consume more memory. Vertical instructions are usually encoded with one or two levels. Encoding means the value of a control field in the microinstruction is a binary code specifying which resource or operation is to be performed. The horizontal microinstructions have the potential of being much more efficient resource managers and consequently are more difficult to optimally design than their vertical counterparts.

Combining the attributes of horizontal and vertical microprogramming results in residual control. This method saves memory by using vertical microinstructions while simultaneously controlling multiple parallel resources via setup registers.

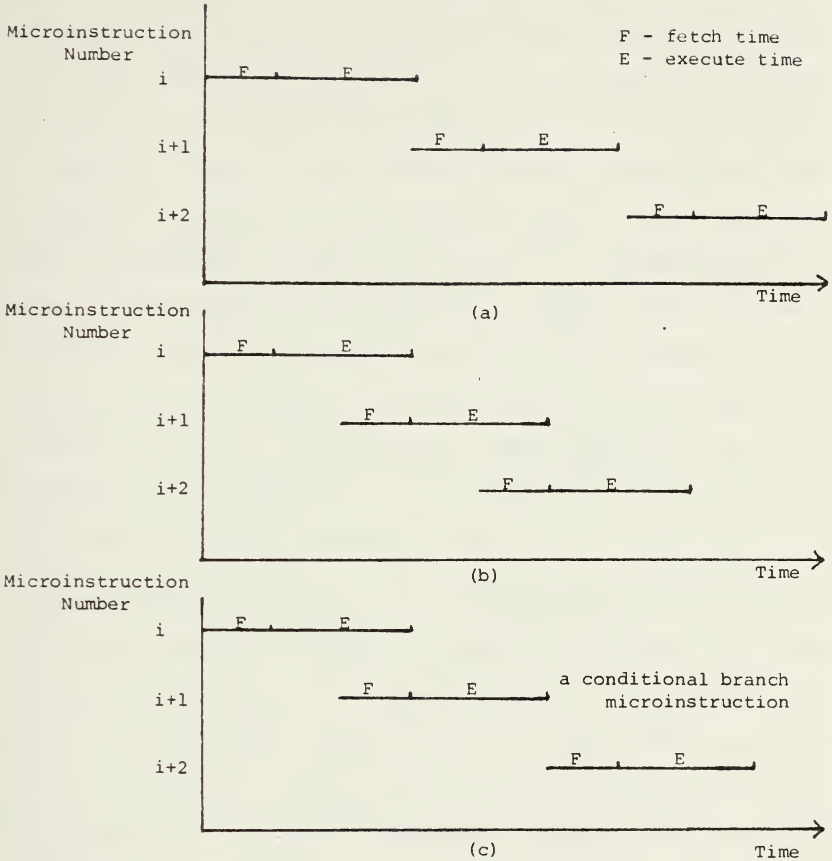
Microinstruction implementation severely effects the speed of microprogram execution. In serial implementation, one microinstruction is fetched and fully executed prior to fetching the next instruction. This technique offers the advantage of logical simplicity while suffering from lack of efficiency since it consumes the maximum amount of time.

'Parallel' implementation permits fetching of the next

instruction before termination of the previous instruction. The obvious advantage is execution speed which is of utmost importance when emulating another machine (Figure II-3) [2].

Another significant microprogramming characteristic is the number of phases used in the execution of each microinstruction. A monophase system means there are no subdivisions of the basic clock pulse and consequently each microinstruction is controlled by the transmission of the leading edge of a clock cycle. In a polyphase implementation scheme, the basic clock cycle is subdivided into minor phases which are independently generated via hardware. Although polyphase operations are more complex and require complicated control, they do permit faster resource manipulation when they are efficiently coded by allowing multiple operations to be performed during the same phase(s).

The microprogrammability of a given computer and the capabilities of its associated microprogramming language are directly effected by the the presence or absence of each of the alternative microprogramming characteristics described above. The microprogramming language spectrum ranges from the lowest level or microlanguage through the assembly languages to the high level procedural languages.



(a) Serial fetch and execute.

(b) Parallel fetch and execute.

(c) Combined serial-parallel where next address depends on conditions in present cycle.

Figure II-3 [2]

The problems of microprogramming can be significantly reduced if suitable software support exists and is readily available. This support is usually in the form of simulators and debuggers. Typically, a simulator provides an alternative to assembly level coding by permitting the user to code in a higher level language and yet achieve the same results at the expense of some added memory and execution time. Debuggers are extremely useful in the developmental stages of microprogramming especially for new and experimental system design. Debuggers permit dynamic access to the machine status and register contents at the instant they are employed, i.e. a trace feature. Some debuggers offer the opportunity of assembling in-line. This option can drastically reduce required debugging time.

The primary application of microprogramming is to implement the necessary control structure required for the analysis and execution of machine level instructions by means of programmed control stores rather than hardwired logic. Therefore, a dynamically microprogrammable computer can provide a software development system which can be a cost-effective approach to experimentation with potential candidates for replacement computer systems or the design of completely new systems to fit the needs of unique applications.

C. THE GOALS OF EMULATION

A well-designed emulation can provide an opportunity to experiment and create software for new computer systems before the actual hardware is available. The utilization of an emulator can almost eliminate reprogramming, consequently smoothing the system transition period. In addition, emulation has provided a workable model of new systems under consideration for procurement, providing a much more detailed cost-benefit analysis of system conversion.

Furthermore, it is often economically sound to emulate a second generation computer with a third generation system. This provides growth to a contemporary system while fulfilling the requirements of the past in a cost-effective manner. However, this can be a disadvantage if the programming staff uses the emulation as a link to the old system and consequently fails to take advantage of the attributes of the new system.

D. EMULATION VERSUS SIMULATION

To accomplish the emulation objectives, certain design features must be incorporated into an emulation. Naturally, execution time and allocated memory are the two foremost considerations. Traditionally, the concept of mimicking another computer has been accomplished by either a simulator or an emulator, two concepts often confused with one another.

A simulator is a series of high level language (HLL) or assembly language statements which individually do not behave like the target machine instructions. The host machine executes its own native instructions in order to imitate the target machine operations. Consequently, simulation is a rather slow technique because it requires an intermediate translation. In addition, simulation of certain instructions such as bit manipulation and shifting operations can require an enormous amount of intermediate code generation demanding a significantly larger memory allocation.

An emulator is a microprogram that is executed on the host machine, performing machine instructions of the target machine. Since an emulator accepts the binary object code of the target machine and directly executes these instructions, it can be extremely efficient in terms of time and space requirements. The execution time of an emulation is dependent upon many factors: clock rates of the two machines, frequency of memory references, high speed shifting compatibility, required register mapping between target and host machines, bit manipulation capability of the two machines, condition code selection and testing, flexible data path selection capability, interrupt similaritites, input/output compatibility, and microprogramming efficiency. If the hardware features between target and host machines are extremely compatible and highly efficient microprogramming has been employed, an emulation performance ratio (host

to target) of nearly one to one can be attained. This emulation performance ratio (EPR) has been demonstrated by the emulation of the SKC-2070 on the Nanodata QM-1 computer. It is possible to achieve an EPR better than one to one under ideal situations, when the host machine has a much faster internal operation execution rate [1].

Several distinct advantages can be realized using emulation as compared to simulation. The execution speed is significantly better by at least an order of magnitude. The target machine representation in firmware is closer to the actual hardware design and total access to the lowest machine level is achievable. Perhaps most noteworthy, emulation provides the opportunity to rapidly create test beds for numerous machine architectures and provide a basis for new system development.

E. EMULATION TECHNIQUES

Traditionally, there have been three approaches for emulating machine instructions: 1) hardware or firmware assistance to a software simulation as demonstrated by the IBM 360/65 emulation of the IBM 7090, 2) independent host system hardware or firmware which provides for complete execution of the target machine's instruction repertoire of which the Burroughs D-machine emulation of the AN/UYK-20 is an example, and 3) an auxiliary processor which is operated in conjunction with the host machine to execute target machine instructions [14].

Software-controlled emulation is usually characterized by categorizing the target machine instructions into three distinct classes: easily emulated instructions, complex instructions not readily emulated, and those instructions not deemed necessary for the desired application. Instruction usage is significant in this classification process. Each class of instructions becomes a candidate for direct hardware or firmware implementation. The first emulated function in this approach is usually the fetch and analysis operation. After the instruction is analyzed, the appropriate opcode subfunction can be executed.

An alternative emulation technique is the firmware-controlled method. This approach is identified by having system control reside completely in firmware or hardware during the emulation process. All instructions are executed on the host machine as if they were indigenous to the target machine. This method is much more efficient than the software-controlled technique; however, it is more expensive and the cost differential is directly related to the required performance level. Performance is dependent upon the number of required data paths, arithmetic units, and other additional logic circuitry which must supplement the host machine architecture.

Upon entering the emulation mode in a firmware-controlled emulator, the machine performs like the target machine until encountering an exit situation. There exists three exit modes: 1) priority interrupt, 2) not implemented

instruction, and 3) deliberate exit because of a debugging routine.

The third emulation technique consists of utilizing auxiliary hardware electronically attached to the host computer for the sole purpose of executing target machine instructions. In effect, a target machine is composed of host machine hardware with the necessary additional components required to create an effective emulator.

F. EMULATION HARDWARE

The development of writeable control stores and microprogramming techniques have significantly influenced computer design. This section will describe some of the available dynamically microprogrammable hardware (Figure II-4).

The Hewlett-Packard 2100 is a general purpose minicomputer. It has a unique control store divided into two segments. One section is ROM and the other section is user programmable. The machine is vertically microprogrammed using a standard 80 instruction machine language repertoire. A debugger and assembler assist the user in microprogram development [2].

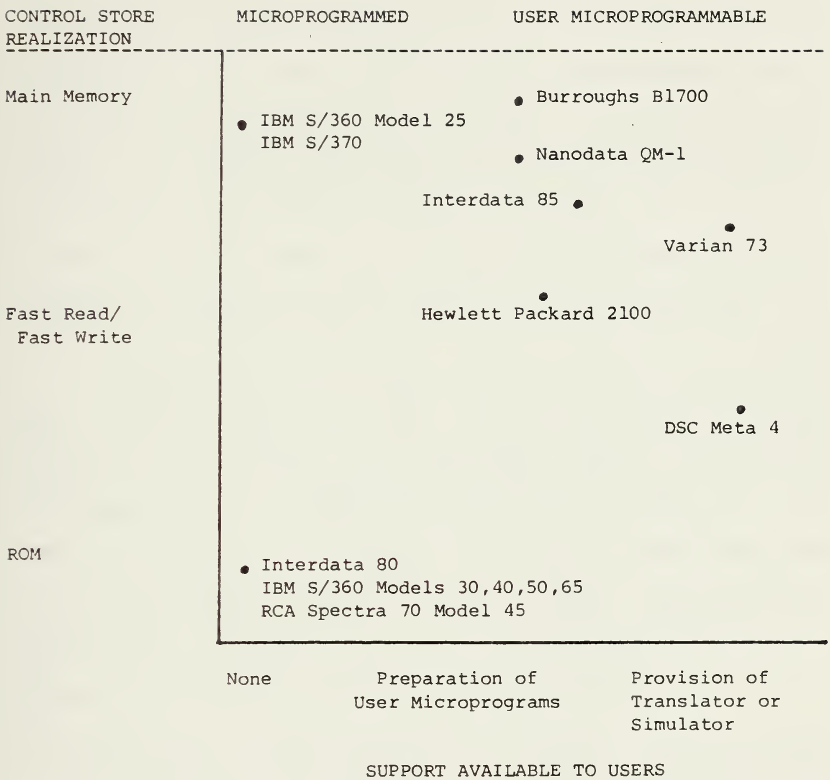
The Standard Logic CASH-8 is a high speed digital controller with a separate control store. It consists of 16 general purpose registers and an accumulator. The CASH-8 is vertically microprogrammed but does not support any language

above microlanguage [2].

The Varian 73 is a general purpose minicomputer that has a 150 instruction set. The horizontal microinstruction consists of 64 bits with 25 fields, some of which indicate register transfers, ALU operations, shifting, control store addressing, condition testing, I/O control and memory operations. The Varian 73 contains both a ROM control store and a writeable control store loadable from main memory. A microprogram assembler and interactive simulator are available [2].

The Nanodata QM-1 is unique in that it contains both a control store and a nanostore which are both loaded under user program control. The 18-bit vertical microinstructions are stored in the control store, fetched and then interpreted under nanoprogram control. A horizontal nanoinstruction is 360 bits which is subdivided into five 72-bit vectors. Assemblers for both microprograms and nanoprograms are available [2].

The previously described machines represent a small sample of the available microprogrammable computer architectures. The availability and flexibility of these computer systems has stimulated demand for these devices. Consequently, hardware manufacturers have been compelled to produce writeable control store equipment to satiate the needs of the computer market.



Note: Relative microprogrammability is the distance from the origin to the machine point in two space.

Figure II-4 [2]

III. AN/UYK-20 ARCHITECTURE

Constructing an efficient emulation requires a precise understanding of the architecture and performance characteristics of the machine being emulated. An emulation must attempt to match the target machine's features and maintain its flexibility of hardware design as closely as possible. Although it is not required, an operational demonstration of the emulated machine can solve many emulation questions.

In emulating the AN/UYK-20, architecture and performance criteria were derived from technical publications, since an actual machine was unavailable. When inconsistencies appeared in the documentation, specific questions were posed to a UNIVAC field engineer, who often tested programs on the AN/UYK-20 to resolve inconsistencies. Documentation coupled with an expert consultant provided sufficient information for emulating the AN/UYK-20 successfully.

The intent of this chapter is to outline those features of the AN/UYK-20 significant to the emulation. A detailed hardware description can be found in Refs. 20, 22, 28.

A. HARDWARE DESIGN

The AN/UYK-20 was designed for the Navy to fulfill the requirements for small or medium size general purpose data processing in shipboard, mobile shelter, or other military environments. Sperry Univac incorporated minicomputer technology in constructing the AN/UYK-20, including MSI circuitry design, microprogrammed control, memory modularity, and asynchronous or synchronous input/output channels.

The AN/UYK-20 had to be extremely flexible in its applications, offering a wide range of configuration possibilities which were derivatives of the basic design. Modularity, a concept highly desirable in a military environment, was achieved by offering options that could be easily added using printed circuit cards and/or memory modules.

The AN/UYK-20 can accomodate up to eight 8K, sixteen-bit word boards of magnetic core storage with an access time of 750 nanoseconds. The central processor is controlled by a programmable micromemory which can be expanded by an additional 512 words. The microprogram controller is programmed at the factory, but the additional micromemory option is user defined. Both sections of micromemory are programmed using fusible links, and once programmed they are completely static (Figure III-1).

A memory interface is responsible for the transfer of data to memory from the central processor (CP) and input/output controller (IOC). Both the IOC and the CP are

capable of accessing all of memory (65,536 words maximum). The addition of direct memory access (DMA) provides a second memory interface and an additional access port which is connected to each of the two 32K memory segments.

The input/output controller permits the central processor to communicate with the external devices without interfering with program execution. The IOC has a maximum of 16 parallel or serial channels. Parallel data transfer takes place asynchronously using 8-bit, 16-bit, or 32-bit transfers. Serial interfaces are either synchronous or asynchronous, with word-to-serial or serial-to-word conversions occurring in the IOC. The IOC and CP compete for memory access through the memory interface with priority given to the IOC in the event of a simultaneous request. The IOC is permanently assigned several memory addresses for command word and interrupt word storage.

The addressable high-speed registers available in the AN/UYK-20 include the program address register (P-register), two 16-bit status registers (SR1 and SR2), a real-time clock register (32-bits), a monitor clock register (16-bits), and a set of sixteen 16-bit general registers. An additional stack of 16 general registers is an available hardware option.

The sixteen general registers were included to enhance the speed and performance of the AN/UYK-20, allowing most programs to use a great proportion of register-to-register

instructions. These general registers can be used as accumulators for arithmetic, shift, or logical functions, as index registers, or as temporary storage locations. The second set of general registers can be readily employed via a status bit. This status bit designates which general register stack is to be utilized. The duplicate set of general registers yields dividends in a multi-task or heavy-interrupt processing environment. This additional register set can be used to provide high-speed temporary storage, thus avoiding slower main memory storage of working variables.

The two 16-bit status registers and the program address register represent the machine status of the AN/UYK-20. When these registers are collectively referenced, they are called the program status word (48-bit PSW). The P-register indicates the next instruction to be executed. This instruction may be a 16-bit single-word instruction or a 32-bit double-word instruction. Program control can be modified by using an instruction which manipulates the contents of the P-register.

Status register 1 contains bit information concerning condition code settings, overflow, and carry bits, interrupt codes, and numerous other machine indications (Figure III-2).

AN/UYK-20 FUNCTIONAL ARCHITECTURE

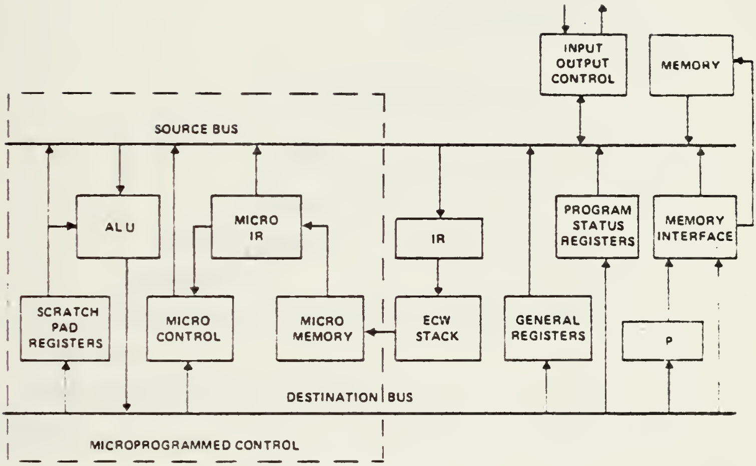
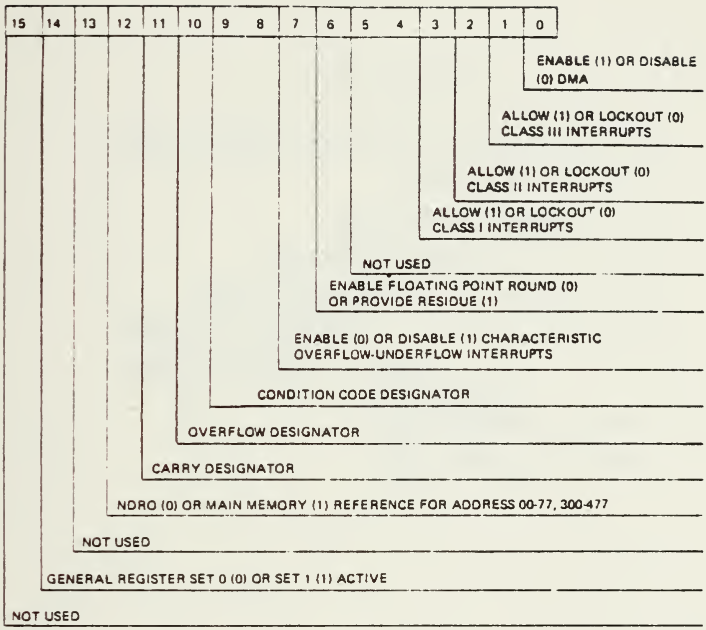


Figure III-1 [22]

STATUS REGISTER 1



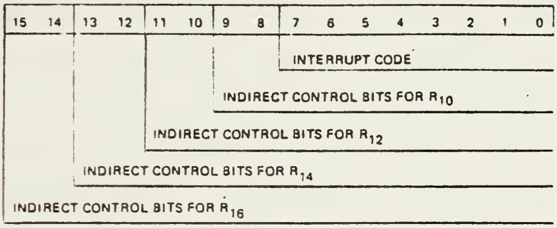
CONDITION CODES

SR BITS 8 and 9	ARITHMETIC	COMPARE
00	0	$(R_a) = (R_m)$ or (Y)
01	>0 (POS)	$(R_a) > (R_m)$ or (Y)
10	Not Used	Not Used
11	<0 (NEG)	$(R_a) < (R_m)$ or (Y)

Figure III-2 [23]

Status register 2 holds control bits for direct or indirect addressing, and holds interrupt codes. Interrupt processing routines set bits in the interrupt code field corresponding to the IOC interrupt (Figure III-3).

STATUS REGISTER 2



INDIRECT CONTROL BITS	MEANING
00	Normal Addressing.
01	Normal Addressing.
10	Indirect Addressing w/o indexing; IW1 at Y = y.
11	Indirect Addressing with indexing; IW1 at Y = y + (Rm).

Figure III-3 [23]

The real-time clock and monitor clock registers provide program-controlled interrupt capability which is useful for timing and synchronizing program segments with real-time events. The real-time clock (RTC) is a 32-bit register used as count-up storage while the monitor clock (MON) is a 16-bit count-down register. A one kHz internal oscillator controls the counting speed of both registers. An optional

external clock operating at a frequency up to 50 kHz is also available.

Interrupt processing in the AN/UYK-20 is conducted using a priority level scheme which classifies interrupts into three priority levels (classes). Interrupts within the same class are assigned a priority ranking and a code which identifies which processing routine to execute. During interrupt handling, all interrupts of the same level or lower level are locked out until the CP is completed processing the current interrupt. Higher priority interrupts can override the lockout and cause the CP to honor them first, holding the lower level interrupts in abeyance until higher level interrupt processing is completed. The highest priority interrupts are hardware malfunctions, followed by software interrupts, and at the lowest level, IOC interrupts.

Permanent locations in memory corresponding to each interrupt class hold the PSW and RTC when an interrupt is being honored. Likewise, other permanent memory addresses assigned to each interrupt class hold the appropriate interrupt routine entrance location to be loaded into the PSW.

Memory addressing is accomplished using 64 page address registers which separate memory into 1024-word pages. Absolute addresses are formed by isolating the upper six bits of the relative address to find the page address register number, and then concatenating the lower six bits of the

page address register contents with the lower ten bits of the relative address (Figure III-4). Any operation that stores into memory sets the most significant bit of the page address register used in generating the address.

Some additional hardware features of the AN/UYK-20 are those functions available on the maintenance panel of the machine itself. These include a breakpoint feature which allows an operator to insert from the panel an address which causes the AN/UYK-20 to stop execution when the selected address is referenced. Other available toggles allow halting execution programmatically using Key 1 or Key 2 on the maintenance panel. These additional hardware features are useful debugging tools.

MEMORY ADDRESS GENERATION

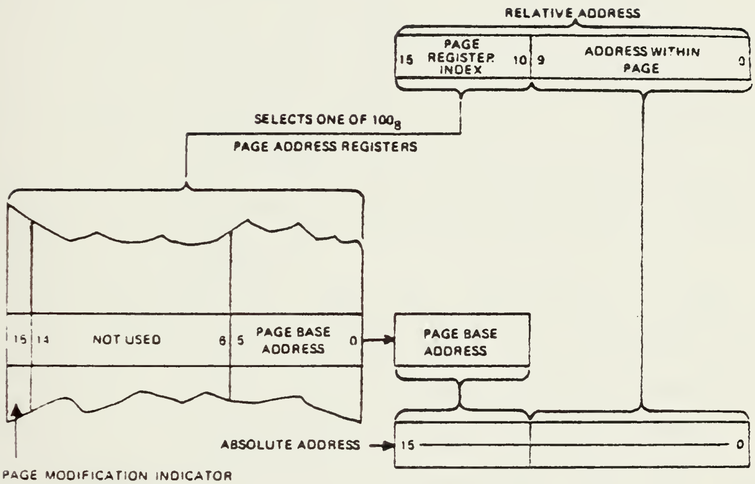


Figure III-4 [22]

B. INSTRUCTION FORMATS AND REPERTOIRE

1. Repertoire of Instructions

The AN/UYK-20 instruction set is composed of nearly 260 separate instructions designed to be both versatile and comprehensive. Both single-word (16-bit) and double-word (32-bit) instructions are available. Some of these instructions are specifically designed to meet the requirements of a real-time environment. A few sample instructions include:

a. Local jump - used to facilitate loops, saving several steps in program execution.

b. Reverse register - used in a communication environment when data is received in one sequence but must be transmitted in reverse sequence.

c. Set bit, clear bit, and test bit - used to test individual bits in registers saving considerable execution time in programs that communicate via flags and status words.

Additional flexibility is provided when the 'math pac' hardware option is included in the AN/UYK-20 configuration. Some 33 additional opcodes are added to the instruction set in order to increase the computational capabilities of the machine. An instruction for square root, double precision multiply/divide instructions, as well as hardware trigonometric and hyperbolic functions which utilize coordinate conversion algorithms (cordic) are included.

Single-word instructions are generally employed when manipulating operands in high-speed registers. Double-word instructions are used in operations involving direct or indirect addressing with or without indexing, or supplying 16-bit constants to programs. Typical instruction speeds for a single-word versus a double-word instruction are:

	SINGLE-WORD	DOUBLE-WORD
ADD	.75 - 1.5 usec	1.5 - 2.25 usec
LOAD	.75 - 1.5 usec	1.5 - 2.25 usec
MULTIPLY	3.8 - 4.0 usec	4.4 - 4.6 usec
DIVIDE	6.8 - 7.0 usec	7.4 - 7.5 usec

Nearly all instructions affect condition bits in status register 1. The AN/UYK-20 sets these bits as a result of two types of operations. Most instructions that do not involve compare logic are categorized as arithmetic instructions. When the result of the arithmetic operation is determined and is about to be stored in memory or a register, a condition code is set indicating whether the result is positive, negative, or zero. Compare instructions set the condition bits based on a greater than, less than, or equal to comparison of two registers or a register and the contents of a memory address.

Two other bits in SR1 are set as a result of computational or shifting instructions. The overflow designator is set whenever an arithmetic or shift operation requires more bits than are provided for in a register (16 bits).

The carry designator is set when an arithmetic operator generates a carry beyond the most significant bit of the register.

The AN/UYK-20 allows five different types of operand formats: single-length, byte, literal, optional floating point, and double-length. Single-length operands are 16-bit values with the sign bit assumed to be in the most significant bit. In arithmetic calculations, the single-length word is assumed to be a two's complement integer. Byte operands are considered 8-bit unsigned integers, and can be the most significant or least significant half-word of a memory location. Literal operands are 4-bit unsigned integers denoted by the 'm' field of a literal type instruction. Floating point operands are formed using two adjacent registers or memory locations with fields containing the sign of the fraction, the characteristic, and 24 bits of the fraction.

Double-length operands are concatenated from two adjacent registers or two adjacent memory addresses. The most significant half of the double-length operand is contained in the low-order register or memory address, and the least significant half in the next sequential register or address. The sign bit for both words resides in the high-order bit position of the most significant half-word and when used in an arithmetic calculation, the double-length operand is treated as a two's complement integer. Instructions involving double-length operands require the low-order

register or memory address to be even, since the adjacent cell address is formed by 'OR'-ing a 1 in the least significant bit of the address.

2. Instruction Format

The AN/UYK-20 has five different instruction word formats, designated by two-letter mnemonic codes. These codes are: RR (Register-Register), RL (Register-Literal), RI (Register-Immediate), RK (Register-Constant), and RX (Register-Index). Each of these formats are designated in the instruction word by a combination of the opcode field and the subfunction code. Registers are identified in the 'a' and 'm' fields of the instruction, and are referred to by the notation Ra and Rm. The 'y' field is treated as an address or arithmetic constant, depending on the instruction (Figure III-5).

The format RR single-word instructions perform operations involving the registers specified by the 'a' and 'm' fields. No memory references are made to access operands, causing considerable savings in execution time. The 'a' or 'm' field may be used to index special operations on registers.

Format RL instructions use a 16-bit instruction word, using one or two general registers. The 'a' designator selects the general register Ra or register pair Ra, Ra + 1. The 'm' designator contains the 4-bit literal value which will be used in the instruction.

INSTRUCTION FORMATS

RR

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Op*						0		a				m			

a selects R_a; m selects R_m.

RL

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Op*						0		a				m			

a selects R_a; m contains 4-bit constants.

RI-1
Local
Jump

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Op*						1		d							

d is signed number of instructions to jump, relative to current position.
(+ is forward; – is backward)

RI-2
Indexed
Memory

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Op*						1		a				m			

a selects R_a; m selects R_m. R_m selects memory address.

RK

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Op*						2		a				m			

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
y															

a selects R_a; $m \neq 0$ selects R_m, $m = 0$ selects 0.
Operand = $y + R_m$ or 0.

RX

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Op*						3		a				m			

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
y															

a selects R_a, $m \neq 0$ selects R_m, $m = 0$ selects 0.
$y + R_m$ or 0 selects memory address.

*Op is operation code

Figure III-5 [23]

RI format single-word instructions are separated into two catagories. RI Type 1 instructions are local jump instructions where the P-register is increased or decreased by the 'd' field in the instruction. The 'd' field represents the two's complement deviation value and allows the P-register to be altered a maximum of +177 octal or -200 octal. RI Type 2 instructions involve operations that use the general registers Ra and Rm, and a memory address specified by the contents of Rm.

The format RK instructions contain 32 bits of information. The upper 16-bits contain the operation code and the designator fields. The 'a' field selects the general register Ra, and the 'm' field denotes how the next word, containing 'y', is to be used. If 'm' equals zero, then the effective operand address Y, equals 'y'. If 'm' does not equal zero, then Y is formed by adding the contents of Rm to 'y'.

Format RX are double-word instructions similar to the RK instruction that use direct and indirect addressing techniques determined by the 'm' field. If the 'm' field equals zero, then direct addressing without indexing is employed, with the effective operand address formed from the 'y' field itself. If the 'm' field equals 1 through 7, 11, 13, 15, or 17 (octal), then direct addressing with indexing is employed. The effective operand address is formed by adding the contents of Rm to 'y'. An 'm' field value of 10, 12, 14, or 16 (octal) indicates indirection is to be

employed, and the indirect address control fields in status register 2 contain information which is used to generate the effective operand address or a pair of indirect words. When the control fields equal 0 or 1, then direct addressing with indexing results. If the control field equals 2, then the contents of the first indirect word (IW1) is located at 'y'. Finally, if the control field equals 3, then IW1 is located at 'y' indexed by the contents of Rm. Indirect word format is shown in Figure III-6. Cascaded indirection is possible provided that the indirect words are properly encoded.

Byte addressing is accomplished using RX format instructions. A byte identifier (B) is used to determine which half-word (8-bit) is to be referenced. If B equals 0, then the most significant half-word in address Y is the operand byte. If B equals 1, then the least significant byte at Y is the operand. The least significant bit in the indexing register is used as the byte identifier, and the remaining 15 bits are used as the indexing value for finding Y. Indirect byte operand addressing formulae are included in Figure III-6. The following formulae apply for direct byte operand addressing:

m=0, Y=y, and B=0

m=1-7, 11, 13, 15, or 17 octal

Y=y + (Rm)/2 and B=LSB of (Rm)

The preceding section has described the fundamentals of the AN/UYK-20 instruction formats. References 21 and 23 should be consulted for further information concerning instruction formats and decoding.

INDIRECT WORD FORMATS

15	14	13 12	11 10 9 8 7 6 5 4	3 2 1 0	
NOT USED	I	J	NOT USED	X	IW 1
IW 2					IW 2

OCTAL J VALUE	ADDRESS DETERMINATION
0	Y = IW2; if byte mode, upper byte is used.
1	Y = IW2 + (Rx); if byte mode, LSB of Rx determines byte. *
2	Y = IW2 + (Rm); if byte mode, LSB of Rm determines byte. *
3	Y = IW2 + (Rm+1); if byte mode, LSB of Rm+1 determines byte. *

I = 0, DIRECT ADDRESSING, OPERAND AT ADDRESS Y

I = 1, CASCADED INDIRECT ADDRESSING, NEW INDIRECT WORD 1 AT ADDRESS Y

* To determine the operand address when in byte mode, the contents of R_x, or R_m, or R_{m+1} are right shifted 1 bit position and zero filled in the left most position

Figure III-6 [23]

IV. BURROUGHS D-MACHINE

A. HARDWARE DESCRIPTION

The microprogramming facility at the Naval Postgraduate School is composed of a Burroughs Interpreter-Based system. This system possesses the characteristic of being dynamically microprogrammable and is designed using a simple building block structure. A typical system is made up of a number of interpreters (processors), main memory modules, and input/output devices, along with a switch interlock device (SWI) controlling data flow on the data bus connecting the interpreters to main memory and peripheral devices. The heart of the system is the interpreter, also referred to as the D-machine.

A D-machine possesses five functional modules: the logic unit (LU), the control unit (CU), the memory unit (MU), nanomemory (NM), and microprogram memory (MPM). The system presently installed in the Computer Science Department combines nanomemory and microprogram memory into one functional unit. The architecture of the D-machine is designed around 8-bit word slices. Word lengths from 8 bits to 64 bits are permissible using the same functional unit (Figure IV-1).

INTERPRETER BLOCK DIAGRAM

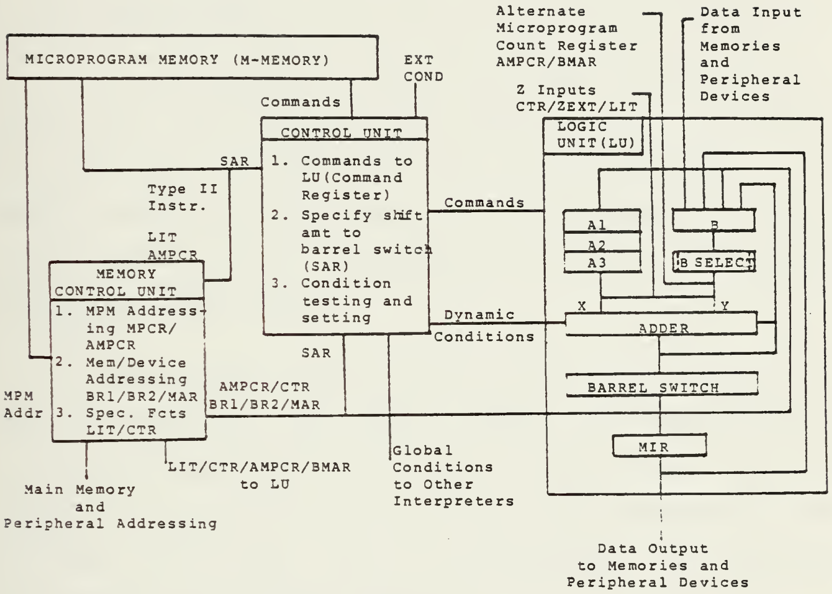


Figure IV-1 [o]

The D-machine used for this thesis has been configured as a 32-bit word processor. Reference 17 provides a thorough and concise description of the architecture of an interpreter-based microprogramming system. Reference 6 details the specifics of D-machine microprogramming which must be thoroughly understood by the programmer.

1. Logic Unit

The D-machine's logic unit performs shifting, arithmetic, and logic functions and contains scratch pad registers and data interfaces for the switch interlock. All adder operations are performed using two's complement arithmetic, and shifting is accomplished in a matrix of gates called the barrel switch.

The scratch pad registers A1, A2, and A3 are identical in function. They act as temporary storage registers within the D-machine and serve as primary inputs to the adder. The control unit determines which register will be an input to the adder. Any of the A-registers can receive the output from the barrel switch.

The B register functions as the primary external input interface from the switch interlock. It acts as the second input to the adder and can receive certain direct inputs from the adder's arithmetic operations. The B register can be loaded from any of the following sources:

a. The barrel switch output.

b. The adder output.

c. External data from the switch interlock (or control panel switches).

d. The memory information register (MIR).

e. The complements of four bit or eight bit carries.

f. The barrel switch ORed with the adder, external data from the switch interlock, or MIR.

The output of the B register is filtered prior to gating into the adder. The 'filter' consists of true/complement selection gates which are divided into three sections: the most significant bit, the least significant bit, and all the remaining central bits. The output of this filter is the independent result of these sections and may be either all zeroes, all ones, or the true contents or one's complement of the contents of the respective bits of the B register.

The memory information register is the interface to the switch interlock. MIR functions as a buffer to main memory or to a peripheral device. It is an output destination of the barrel switch and its output can be sent to the B-register or the switch interlock.

The adder in the logic unit performs all arithmetic functions and can be categorized as a version of a carry look-ahead adder. The control unit can gate various combi-

nations of A, B, and Z inputs to the adder. An 'A' input is defined as an input from one of the three scratch pad registers. A 'B' input is the output of the B register's true/complement filter gates. A 'Z' input is an external input to the logic unit and can originate from one of the following sources:

a. The output of the counter in the memory control unit (MCU) which is gated to the most significant eight bits of the adder with the remaining bits zeroed.

b. The output of the literal register in the MCU which is gated to the least significant eight bits of the adder with the remaining bits zeroed.

c. An optional input which is gated into the middle bytes of the adder with the most and least significant bytes zeroed.

d. The output of the alternate microprogram count register (AMPCR) in the MCU which is gated into the least significant 12 bits of the adder (13 bits for 8K micromemory machines) with all other bits being zeroed.

e. All zeroes.

Two inputs, selected from the A, B, or Z sources, are always gated to the adder. These inputs are referred to as X-select and Y-select. An X-select input may be either an A input or a Z input. If it is not specified, it is

assumed to be zero. A valid Y-select has either a B, Z or 1 as its input. Some Z inputs, however, are valid only as Y-select inputs. Any combination of valid X-selects and Y-selects are permissible addends, with an option of adding a one to the least significant bit. For subtraction operations, the value to be subtracted must be a Y-select; the Y-select input is subsequently two's complemented and gated to the adder. All binary Boolean operations between two adder inputs are allowed, and dynamic condition bits for overflow (AOV), all bits true (ABT), and most/least significant bit test (MST/LST) are available to the control unit for testing. Bit testing is a valuable feature for decoding instruction words.

The barrel switch is a matrix of gates that accepts parallel data from the adder and shifts the data any number of places to the left or right with zero fill. It also can right shift the word in an end-around fashion. The output of the barrel switch may be directed to any of the following destinations simultaneously:

a. The A registers.
b. The B register.
c. The memory information register.
d. The least significant 16 bits to the MCU registers.
e. The least significant three to six bits to the control unit shift amount register (bit length depending on the word size of machine).

2. The Control Unit

The control unit has five major sections: the shift amount register (SAR), the condition register (COND), part of the control register (CR), the décoder for microprogram memory content, and clock control. This module of the D-machine manages the functions of the processor, and is directly responsible for logic unit operation.

SAR and its associated logic control shifting operations by loading shift amounts into SAR and generating the required controls indicated by the current microinstruction for the barrel switch. In addition, the SAR's logic generates the 'word length complement' of the SAR contents where the complement is defined to be that amount which would restore the bits of a word to their original position after an end-around shift of N followed by an end-around shift of the 'complement' of N. For example, if an end-around right shift of 20 was required in a 32-bit D-machine, another end-around shift of the complement of 20 (12) would be required to restore the contents to its original value.

The condition register has four major functions:

a. It stores 12 resettable bits which are used as error indicators, interrupts, status, and lockout indicators.

b. It selects one of 16 condition bits for performing conditional operations. These 16 bits are composed of the 12 condition bits of the

condition register plus the 4 dynamic conditions generated by the LU adder during the present clock time.

c. It decodes bits from the memory for resetting, setting, or requesting the setting of designated bits of the condition register.

d. It resolves priority between interpreters in the setting of global condition bits (GC), thereby providing a method of controlling inter-interpreter lockout.

The control register stores the control bits of the 56-bit microinstruction that are not being used in the first phase of the execution cycle. The control register is subdivided into sections which are used by the memory control unit, the logic unit, and the control unit during the execution phase of a microinstruction. For a description of timing and phases, see section C of this chapter.

3. Memory Control Unit

The memory control unit provides the basic addressing interface between the D-machine and both main memory (S-memory) and microprogram memory (M-memory). One MCU can address 64K words (256K bytes) of main memory, and if the D-machine is configured with a second MCU, a maximum of 128K words can be addressed.

The memory control unit has three major sections:

a. The microprogram address section controls the addressing of microprogram memory and the sequencing of microinstructions. It contains the microprogram count register (MPCR), the alternate microprogram count register (AMPCR), the incrementer, the microprogram address controls register, and their associated logic. For standard 4K M-memories, the MPCR and AMPCR are 12 bits long. For 8K M-memories, MPCR and AMPCR are 13 bits in length (the D-machines installed at the Postgraduate School employ 8K M-memories). AMPCR is a Y-select input to the logic unit adder.

b. The memory/device address section contains the 8-bit memory address register (MAR), two 16-bit base registers (BR1 and BR2), output selection gates, and associated control logic. When forming a memory address, the lower eight bits of a base register and MAR are concatenated. The concatenated 24-bit contents of BR1/ BR2 and MAR (BMAR) is a valid Y-select input to the logic unit adder.

c. The Z register section contains two registers which are Z inputs to the logic unit adder. The literal register (LIT) is an 8-bit register into which constants are loaded. An 8-bit counter (CTR) is used in conjunction with a counter overflow condition bit to control iterative

looping. The Z register section also contains selection gates for the loadable counter and its associated logic.

4. Microprogram memory (M-memory)

A D-machine may have a dual or single microprogram memory scheme. As indicated earlier, the D-machines used in this emulation project had a single microprogram memory, consolidating the microprogram memory and nanomemory into one 56-bit programmable store memory, often referred to as M-memory. Microprograms, consisting of 56-bit microinstructions, are dynamically changeable by the user, thus distinguishing the D-machine as an extremely flexible computing device.

The sequencing of microprogram instructions is controlled by a condition bit procedure which determines the successor command to be executed. M-memory provides data to the condition testing logic which then determines which condition is to be tested. The output of the condition testing logic is a true/false signal that is gated to the successor selection logic. This logic then selects between the three true and three false successor bits also provided by the M-memory word. The three selected bits provide eight possible successor combinations:

a. WAIT Repeat the current instruction.

b. STEP Step to the next instruction.

c. SKIP Skip the next instruction.

d. JUMP Jump to another M-memory address.

e. RETN Return from a microprogram subroutine.

f. CALL Call a microprogram subroutine.

g. SAVE Step and save the instruction address.

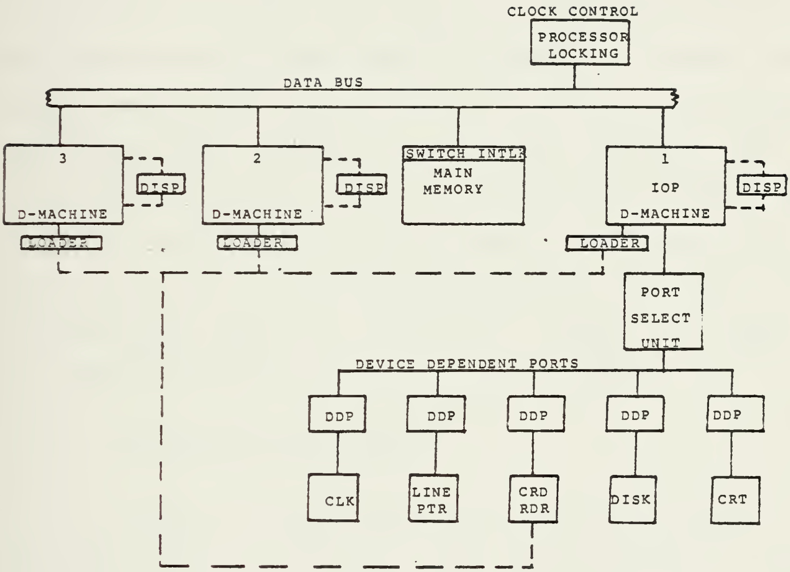
h. EXEC Execute one instruction out of sequence.

The particular successor command chosen controls gates which select the appropriate M-address from MPCR or AMPCR and provides incrementing logic for generating the next M-memory address. Except for the EXEC command, the MPCR is loaded with this M-memory address.

B. NPS MICROPROGRAMMING FACILITY

1. Physical Description

The Computer Science Department of the Naval Postgraduate School possesses a Burroughs Interpreter-Based System consisting of three interpreters (processors) also known as D-machines, a 64K 32-bit word, main memory module, a card reader, a dual cartridge disk drive, a line printer, and a Datamedia 2500 CRT functioning as a supervisor's console (Figure IV-2). All input and output is performed through a single D-machine processor, hardware configured with device dependent ports (DDP) for peripherals and the external clock.



NAVAL POSTGRADUATE SCHOOL MICROPROGRAMMING FACILITY

BURROUGHS INTERPRETER-BASED SYSTEM

Figure IV-2

After initial light-off and bootstrap, the system is configured into two Burroughs 6700 - LIFO ALGOL Stack-machines, each addressing 32K of memory and each communicating with the input output processor (IOP) in a pseudo-multiprocessing environment. Software, written in ALGOL, is provided which runs on the B-6700 system. A resident monitor control program and disk file manager control the maintenance of system files and the execution of jobs in a batch environment. Both D-machines compete for system jobs input from the card reader or CRT. Other software available includes an ALGOL compiler (a derivative of ALGOL 60), a microprogram translator called TRANSLANG, a line editor, and a simulation program for microprograms. TRANSLANG provides the medium by which microprograms are written. User microprograms loaded into a D-machine change its identity and destroy the Stack-machine previously loaded.

2. Input/Output Interface

Pivotal to the operation of the Burroughs system is the input/output interface. Only one processor, the IOP, communicates with peripherals, and the other D-machines, configured as Stack-machines, must compete for its services. The IOP communicates asynchronously, using a conventional 'handshake' method. Since all interpreters have access to the main memory module, a communications link has been established using the upper two 32-bit words of main memory. If a Stack-machine wishes to communicate with the IOP, it places a message into address 65,535 known as the 'mailbox',

and issues an interrupt (INT) to the IOP. The IOP periodically tests INT, and if set, will retrieve the contents of the mailbox (and mailbox - 1 if required) and perform the desired operation. The other Stack-machine is locked out from interrogating the IOP until it has completed processing the request. Normally, the operation requires transferring a buffer to some output device. When the IOP has completed honoring the request, it places a completion code in the mailbox and sets INT for the Stack-machine requesting the I/O. This interpreter must halt execution and check mailbox to see if the I/O was performed successfully, completing the handshaking process. This protocol permits both Stack-machines to perform input/output independently of each other, provided both maintain strict memory boundaries.

Another function of the IOP is interfacing character code formats between the peripherals and the other two D-machines. When the machines are configured as Stack-machines, characters are passed to the IOP in 6-bit BCL (Burroughs Common Language). The IOP must convert this character set to ASCII for output to the line printer and CRT. A similar translation must be made for input data converting from either EBCDIC or ASCII depending on whether the input source is the card reader or the CRT.

3. Memory Interface

Since all three D-machines must share the 64K of main memory, a priority scheme was developed to resolve

memory reference conflicts. The main memory module is actually a single-ported, 32-bit word, core memory which can be made to appear multiported using a switch interlock unit (SWI) developed by Burroughs. The switch interlock controls the main data bus of the system, and resolves conflicts using a priority scheme. The D-machine with the highest priority is the IOP, with the priority of the other two machines being relative to their physical proximity to the IOP. Once a memory reference has been made, a D-machine may continue execution without waiting for a completion signal from the switch interlock. Although this technique of memory referencing minimizes unnecessary delay, it restricts the program from changing the read or write addresses or the content of MIR (write only) prior to a completion signal.

C. MICROINSTRUCTION TIMING

The Burroughs D-machine initiates a microinstruction once every clock cycle. The D-machines utilized for the AN/UYK-20 emulation operated from a one mHz internal clock, which produced a clock pulse once every microsecond. A D-machine designed with an eight mHz clock, emitter-coupled logic (ECL), and a faster memory cycle time, however, could execute eight times faster. This implies that advances in circuit technology can permit emulations to achieve improved speed and performance with no change in the microprograms.

Every microinstruction is executed using one or more sequential time periods, called phase 1, phase 2, and phase

3. A phase is a constant interval of time equivalent to one clock duration measured from the trailing edge of each successive clock pulse. Some microinstructions only require phase 1 to complete execution. Some require phase 1 and phase 3, and still others require phases 1,2, and 3. A new microinstruction is initiated at each clock cycle, allowing for overlapping of microinstruction execution in phase 1 and phase 3.

Microinstructions consist of two types. In a type 1 microinstruction, events can take place in all three phases:

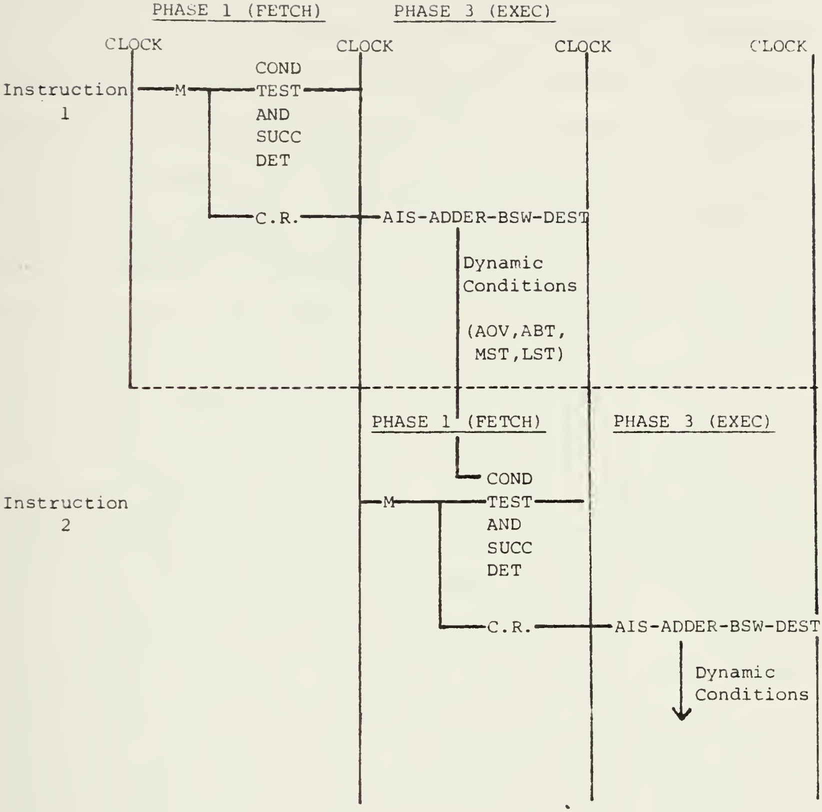
Phase 1: condition testing, (conditional) external operations or (conditional) logic operation initiation after completion of a prior logic operation, and successor M-memory address control.

Phase 2: a holding phase for phase 3 logic operation controls.

Phase 3: the completion phase for logic unit operations and destination register gating specified by logic operation.

During the optional phase 2 period, a type 1 microinstruction execution completion is held in abeyance while a subsequent type 2 instruction is executed. A type 2 microinstruction requires only phase 1 to complete execution, and involves literal assignments to three registers: LIT, SAR, and AMPCR. Phase 2 may also be initiated if the

next sequential type 1 instruction does not execute its conditional logic operation and therefore can complete its execution in phase 1 (Figure IV-3). Appendix D of Ref. 6 has a complete discussion of microinstruction timing.



M - MPM ACCESS TIME
COND TEST AND SUCC DET - CONDITION TEST AND SUCCESSOR DETERMINATION
BSW - BARREL SWITCH
DEST - BARREL SWITCH OUTPUT DESTINATIONS; I.E., REGISTERS (B,CTR,ETC.) AND THEIR INPUT LOGIC
C.R. - COMMAND REGISTER AND ASSOCIATED LOGIC
AIS - ADDER INPUT SELECTION FROM COMMAND REGISTER

Timing Analysis, Type I Instructions

Figure IV-3 [17]

D. TRANSLANG

Microprogramming on the D-machine is accomplished using a microtranslator/assembler called TRANSLANG. TRANSLANG allows the programmer to write microinstructions mnemonically without concentrating on the bit patterns that compose the microinstructions themselves. TRANSLANG is written in ALGOL, the language of the B6700 Stack-machine. Nearly the entire language of TRANSLANG is composed of reserved words recognized by the ALGOL program. Each reserved word has a special meaning which causes the translator to construct particular microinstructions. A TRANSLANG instruction is equivalent to one microinstruction consisting of the set of parallel D-machine functions performed during the clock phases. TRANSLANG is a free form language and instructions may be written in almost any order. Multiple instructions may appear on a line, separated by a period '.'. TRANSLANG constructs include iterative mechanisms, input/output, assignment functions, control transfers, and Boolean, and computational operations. In addition, TRANSLANG permits label definitions and symbolic references for program control flow. Reference 6 is the programming manual for TRANSLANG and contains the complete syntax for the language. Appendix A of Ref. 10 documents additions to the TRANSLANG instruction repertiore.

A microprogrammer may construct complicated microinstructions that perform many different tasks, some interacting closely with D-machine clock timing. Microinstruction

gating to several devices permits a single TRANSLANG instruction to accomplish some or all of the following actions:

a. test a condition.

b. set/reset a condition.

c. initiate an external operation.

d. add.

e. shift the result of an add.

f. store the result into several registers.

g. increment a counter.

h. complement a shift amount.

i. determine the successor microinstruction.

By judiciously composing his microprogram, a programmer may minimize execution time by taking advantage of microinstruction phase overlap and using highly parallel microcode.

The TRANSLANG assembler constructs an object program consisting of non-relocatable 56-bit microinstructions. TRANSLANG maintains a cross reference table that resolves label references during assembly. The object code created is stored on a disk and may be loaded into the micromemory of a D-machine using a special control word recognized by the operating system. Once loaded, the D-machine assumes the control structure dictated by the users microprogram.

V. AN/UYK-20 EMULATOR

A. EMULATION DESIGN

1. Functional Components

The architecture of the AN/UYK-20 emulator microprogram was developed using general guidelines provided by references and previous emulation experience on Burroughs D-machines [10]. The first decision incorporated in the emulator design was to integrate the entire emulation within one D-machine. Since the D-machines had the capacity to handle nearly 8K of microinstructions, no microprogramming capacity limitations were envisioned. The design objectives of a modularized, well-documented, structured microprogram could also be realized.

With the emulator entirely contained in one D-machine, several secondary benefits also existed. First, the emulator was more immune to hardware problems. If one D-machine was malfunctioning, the emulator could still be run on the alternate D-machine. Second, it was possible to have two AN/UYK-20 emulators resident in the system at one time. Not only would two emulators speed up testing of the individual emulation, but they would also permit their eventual use in a system configured for AN/UYK-20 multiprocessing. The third and final benefit of a totally integrated

emulator was recognized during the design of the input/output controller (IOC). Since the AN/UYK-20's IOC was capable of independent processing, an emulation of its IOC would not be possible within the same D-machine. An emulation of the IOC could be accomplished in a second D-machine, which would behave as an independent channel for the D-machine configured as the AN/UYK-20 processor. Although this emulation does not attempt to emulate the AN/UYK-20 IOC, the fact that a second D-machine exists makes its implementation a realistic extension to the project.

The emulator program organization was created following the basic guidelines of Ref. 17. The loader occupied the lowest section of M-memory with the emulator microcode following sequentially. Microprogram control passed from the loader to the emulator via the execution of a 'G' card which signified execution commencement.

The emulator microprogram was organized into three modules positioned such that forward address referencing would be minimized in the TRANSLANG assembler to save time and space. The utilities section was in the lowest portion of the emulator, since its routines were referenced frequently by the succeeding sections. Individual subroutines within the utility section were organized alphabetically.

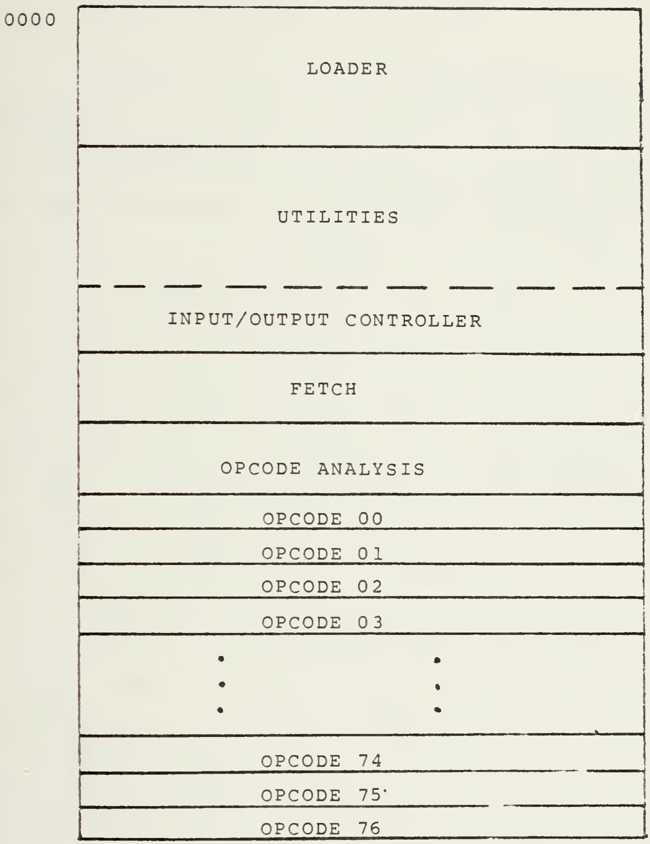
The instruction and memory fetch routines comprised the next module. These routines incorporated all fetch options available in the AN/UYK-20 emulator.

The opcode routines occupied the last section of the emulator. The opcodes were arranged numerically with further indexing determined by the remaining fields of the individual instruction. Figure V-1 shows the M-memory mapping of the AN/UYK-20 emulator layout. Appendix F contains the emulation program listing.

2. Main Memory Organization

Of primary importance in the emulation design was the logical organization of the Burroughs system's main memory. Since the AN/UYK-20 was a 16-bit word machine, it was decided that only the lower half-word of a Burroughs 32-bit word would be used by the emulator. This design restriction permitted the addressing structure of the AN/UYK-20 to be directly projected on the D-machine. A one-to-one correspondence between the memory address of the AN/UYK-20 and the Burroughs system was also achieved.

Since the number of high-speed registers available in the D-machine was small, a 1K portion of main memory was reserved for the AN/UYK-20 addressable register set, the page address registers, the temporary storage space, and the emulation buffers. The mapping of the AN/UYK-20 high-speed registers to main memory greatly simplified the microprogramming requirements of the emulation, but added considerable execution time overhead. Memory access times for the mapped registers were much slower than the actual transfer



AN/UYK-20 EMULATION ORGANIZATION

Figure V-1

rates of the AN/UYK-20 registers. Figure V-2 shows the complete main memory mapping of the emulation reserved storage area.

3. Emulation Program Status Word

Although the emulation duplicated all the AN/UYK-20 registers, the registers which comprised the program status word (PSW) possessed unique characteristics. Status register 1 was combined with the program address register to form a single 32-bit PSW. The emulator's PSW always co-existed in the A1 register of the D-machine and in main memory during execution of AN/UYK-20 programs. The fields of SR1 were modified to include certain emulator toggles, along with the normal condition bits (Figure V-3). The condition bits for DMA and non-destructive read only (NDRO) mode were removed from the SR1 since they were hardware features of the AN/UYK-20 that would not be emulated.

Status register 2, the remaining 16 bits of the AN-UYK-20's PSW, was not resident in any D-machine registers during emulation execution for two reasons: the emulation could not afford the luxury of 48 bits of reserved register space, and SR2 was less frequently referenced than SR1 and the P-register. Consequently, SR2 had to be read from its reserved location in main memory. The contents of the upper 16 bits of SR2's memory location also contained additional emulation toggles which were used by the debugger package (Figure V-3).

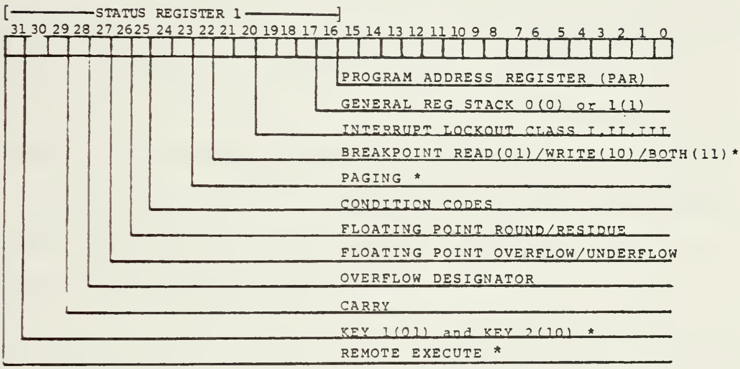
MAIN MEMORY MAPPINGS

DECIMAL ADDRESS	OCTAL ADDRESS	USE
0 - 15	0 - 17	GENERAL REGISTER STACK 1
16 - 31	20 - 37	GENERAL REGISTER STACK 2
32	40	PROGRAM STATUS WORD
33	41	BREAKPOINT REGISTER
34	42	STATUS REGISTER 2 (SR2)
35	43	NEXT LOAD ADDRESS
36	44	CLOCKTIME
37	45	REAL TIME CLOCK
38 - 43	46 - 53	WORKSPACE (TEMP STORAGE)
44 - 49	54 - 61	STACK (TEMP STORAGE STACK)
50 - 53	62 - 65	I/O COMMAND WORDS (IOCW)
54 - 119	66 - 167	UNUSED
120 - 121	170 - 171	HEX ADDRESS FOR INPUT
122 - 141	172 - 215	INPUT CARD BUFFER
142 - 152	216 - 230	UNUSED
153 - 185	231 - 271	OUTPUT PRINT BUFFER
186 - 205	272 - 315	CRT BUFFER
206 - 229	316 - 345	ERRORLIST
230 - 767	346 - 1377	UNUSED
768 - 1023	1400 - 1777	PAGE ADDRESS REGISTERS

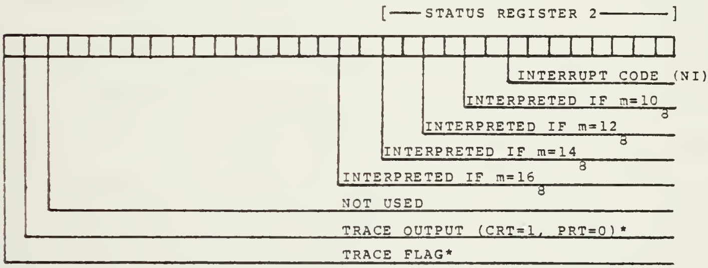
Figure V-2

AN/UYK-20 EMULATION
PROGRAM STATUS WORDS (PSW)

ACTIVE PSW: RESIDES IN LU REGISTER A1 (MEMORY ADDRESS 32)



INACTIVE PSW: RESIDES IN MEMORY ADDRESS 33



* FIELDS ADDED FOR USE BY THE EMULATOR

Figure V-3

4. D-Machine Registers

With only a limited number of high-speed registers available in the D-machine, the emulation design had to include a well-developed plan for their usage. Since only seven registers in the D-machine were 16 bits or longer, they were used exclusively for manipulating the AN/UYK-20 addresses, instructions, and data. The register environment had to be consistent throughout every execution cycle to allow utility routines to be called in the same manner by all opcode subroutines. The primary goal of the emulation was to use as few memory references as possible to conserve execution time and memory space. Judicious use of the existing registers was a necessity.

Several factors had to be considered before selecting a register for a particular function. The most important consideration was its flexibility within the D-machine. The B register, for example, was used as a general purpose register, since its contents could be gated through a masking filter prior to being utilized. A second factor was the type of operand it could contain. Double-word operands (32-bit) could only be stored in the 32-bit logic unit registers while 16-bit operands could also be stored in the memory control unit registers.

The A1 register contained the emulation's 32-bit program status word (PSW) at the commencement of the emulator program. It was not affected by individual instruction

microcode, except when incrementing the PAR, or when a particular instruction modified the PSW. Emulator toggles resident in SR1 could not be altered by an AN/UYK-20 instruction because their settings were independent of program execution.

The A3 register held the instruction word for the duration of its execution cycle. Each field of the instruction could be decoded and interpreted from the A3 register without having to retrieve it from memory. Once the instruction had been completely decoded, A3 was made available as a scratch pad register.

The A2 and B registers were used as scratch pad registers during each opcode execution cycle. In general, their contents were volatile, except when they were specifically documented in the the program listing. The contents of A2, for example, was not altered in the EMULIN subroutine, because of its use in the calling fetch routine. A2 and B were manipulated as either single or double-word operands during the arithmetic operations.

The only remaining logic unit register was the memory information register (MIR). MIR was used for storing information into memory and as a temporary storage location. Intermediate results were deposited in MIR during instruction execution and returned through the B register.

The base registers, BR1 and BR2, were used as storage for addresses and single-length operands, and for

temporary storage of intermediate results. In addition, all memory addressing in the emulation was accomplished using the lower 8 bits of BR2 and MAR (MAR2). These memory control unit registers had to be used carefully, because they required a sequence of several microinstructions to properly reference their contents.

B. LOADER

The loader incorporated into the AN/UYK-20 emulation provided a simple mechanism for loading AN/UYK-20 instructions into main memory (S-memory) of the Burroughs microprogramming system (Figure V-4). Its control word repertoire was flexible, allowing a variety of AN/UYK-20 program environments. Job control statements were included to execute and halt individual programs anywhere in S-memory.

The loader module consisted essentially of a scanner and a translator written in the microcode. Information was read into a 20-word buffer from cards or CRT input, then the buffer contents were scanned for control code consisting of one or more characters. Once these characters were interpreted, control was passed to the translator section which decoded the rest of the data in the buffer and performed the required function. The translator section consisted of a variety of routines that handled specific control words in the loader repertoire. The loader control statements, however, had to appear in a logical sequence (See Appendix A). All loader control statements are contained in Appendix B.

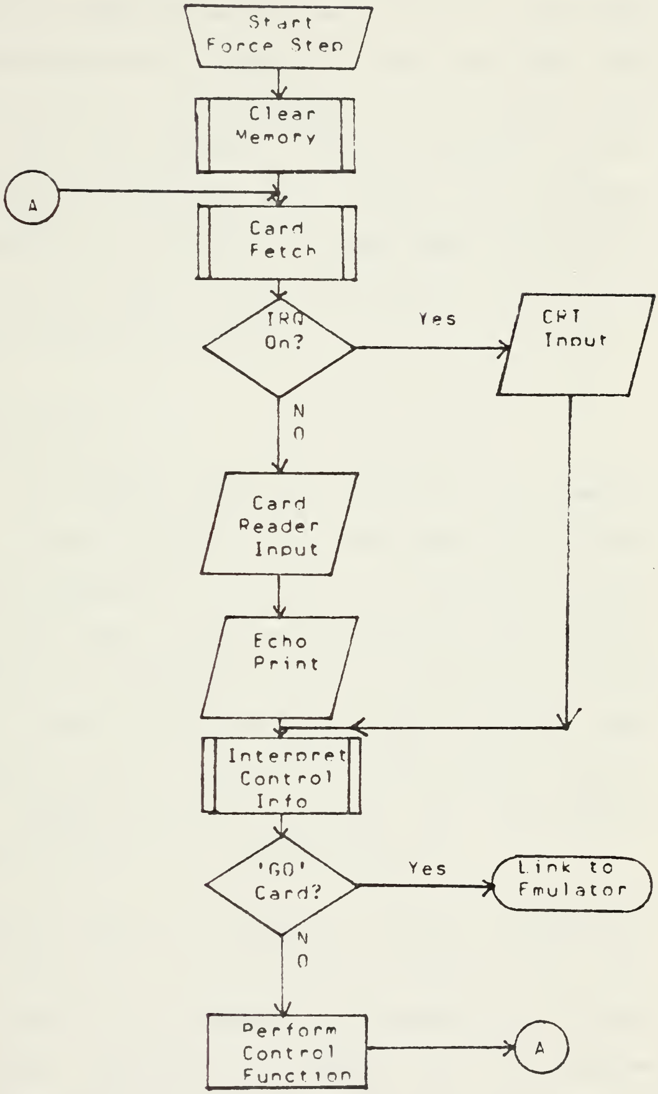

Start
Force Step
Clear
Memory
A
Card
Fetch
IRQ
On?
Yes
CRT
Input
N
O
Card
Reader
Input
Echo
Print
Interpret
Control
Info
'GO'
Card?
Yes
Link to
Emulator
N
O
Perform
Control
Function
A

Figure V-4

The actual interface pipeline between the loader and the emulator consisted of two small emulator utility routines which started and stopped the external clock of the Burroughs microprogramming system. These routines were inserted for emulation timing purposes, and provided a 'stop watch' for AN/UYK-20 programs. The time recorded (in milliseconds) by this 'stop watch' was placed in a reserved memory location in the emulation memory map, and could be read using either a trace control instruction ('T'), or a machine status control word ('M').

C. THE FETCH MODULE

In order to emulate AN/UYK-20 execution and memory referencing, fetch microcode was developed which incorporated memory addressing algorithms and instruction fetch routines. Since both data and instructions were equally accessible from the processor, the memory addressing scheme was closely linked to the instruction fetch concept. Data and instructions could be interspersed throughout memory, and proper program execution required that the program address register point to an instruction word.

The emulation used two routines for memory addressing, EMULIN for reading, and EMULOUT for writing (Figures V-5, V-6). These subroutines performed both paging and breakpoint checking, depending on toggles set in the program status word. Paging was incorporated into the emulation in order to gauge the execution overhead required in emulating

the AN/UYK-20's paging scheme. The paging scheme implemented in the emulator divided main memory into 256-word pages, instead of 1024-word pages used by the AN/UYK-20. Since the Burroughs D-machine was organized for 256-word pages, the microprogramming required for the paging was straightforward. The 256 page address registers resided in the emulator's memory mapping, each initialized to the page number corresponding to their relative address (0-255). The paging algorithm imitated the AN/UYK-20's method of page addressing, and included the setting of a page modification bit.

The breakpoint option was added to provide a method of debugging AN/UYK-20 programs, once the emulation was completed. EMULIN and EMULOUT tested toggles set in the PSW to determine if breakpoint read, write, or both was desired.

The memory addressing convention required all memory references from 1K to 64K to use EMULIN and EMULOUT. All memory references to the memory mapping area (0-1023) did not use these routines, but instead utilized absolute memory referencing microcode.

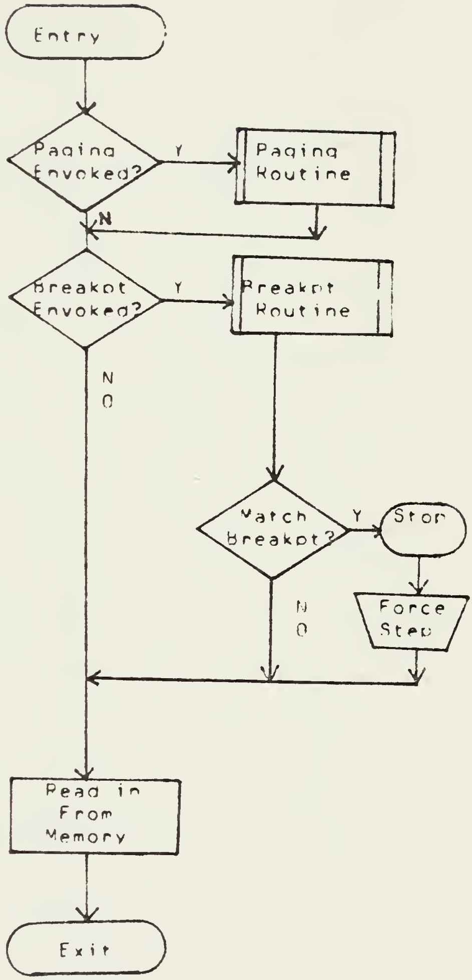

Entry
Paging Envoked?
Y
Paging Routine
N
Breakpt Envoked?
Y
Breakpt Routine
NO
Match Breakpt?
Y
Stop
NO
Force Step
Read in From Memory
Exit

Figure V-5

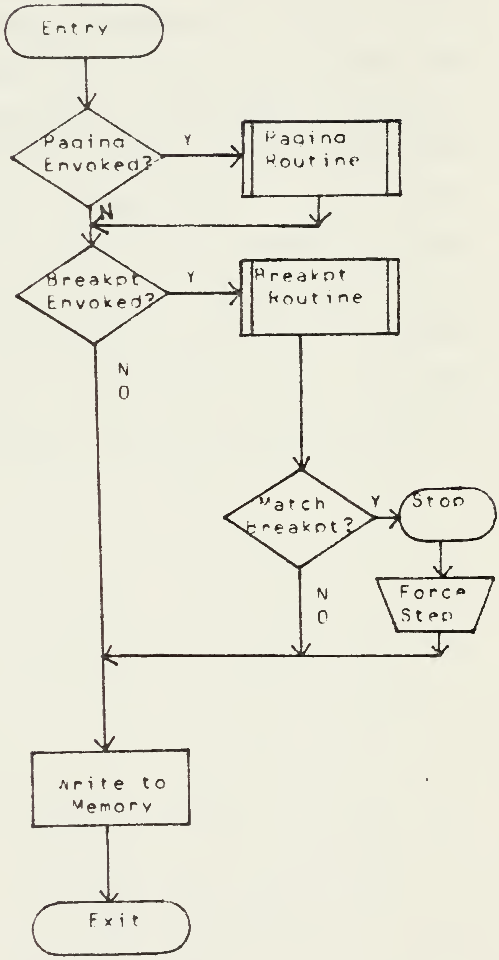

Entry
Paging Envoked?
Y
Paging Routine
N
Breakpt Envoked?
Y
Breakpt Routine
NO
Match Breakpt?
Y
Stop
Force Step
NO
Write to Memory
Exit

Figure V-6

The instruction fetch routine (IFETCH) retrieved instructions from main memory based on the contents of the program address register. Since IFETCH used EMULIN to read the instructions from memory, it could operate in a paging environment, with or without breakpoints (Figure V-7). IFETCH was also responsible for incrementing the PAR, and for testing the trace toggle prior to fetching an instruction. IFETCH was capable of retrieving any instruction word in the program address space (1024-65,535). In the event that the upper memory limit was reached, IFETCH would set the PAR to 1024 and continue execution. Trace toggle testing was inserted into IFETCH as part of the built-in debugging package. Since IFETCH was called prior to every instruction, it was the logical choice for placing a call to the debugger.

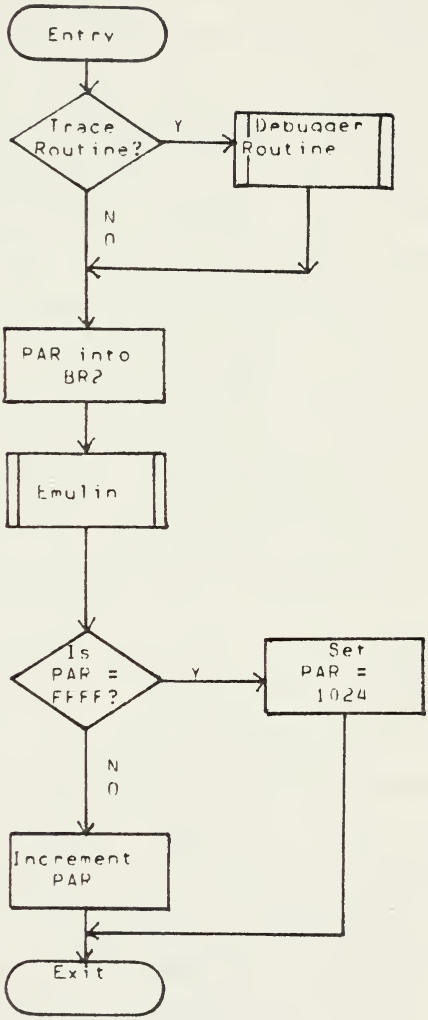

Entry
Trace Routine?
Y
Debugger Routine
N
O
PAR into BR2
Emulin
Is PAR = FFFF?
Y
Set PAR = 1024
N
O
Increment PAR
Exit

Figure V-7

D. OPCODE IMPLEMENTATION

All of the 205 individual instructions emulated were microprogrammed using an identical instruction decoding mechanism. The routines that performed the required operations were terminal nodes on a large tree network, whose root was the OPCODE routine. OPCODE fetched an instruction and isolated the operation code field. The binary value of the opcode field was an index to an operation jump table containing individual opcode M-memory addresses. Within each opcode routine was microcode which isolated the sub-function 'f' field of the instruction and used its value as an index to the next level of opcode analysis. Depending on the opcode, this last jump could identify which instruction was to be performed. If it did not, further analysis of the 'm' or 'a' fields provided the final index to the instruction. Instruction formats are described in Appendix C.

After the instruction had been executed, control passed back to the opcode routine, and then the execution cycle was repeated for the emulation of the next AN/UYK-20 instruction. The AN/UYK-20 programmer could cause this microprogram loop to be exited by either inserting an executive return instruction (03,0,a,00) which caused a 'priority interrupt' and halted program execution, or by coding an instruction that was not implemented, not assigned, or caused a division overflow. The last three cases caused an execution fault, while the former resulted in normal program termination (Figure V-8).

AN/UYK-20 EMULATION GENERAL STRUCTURE

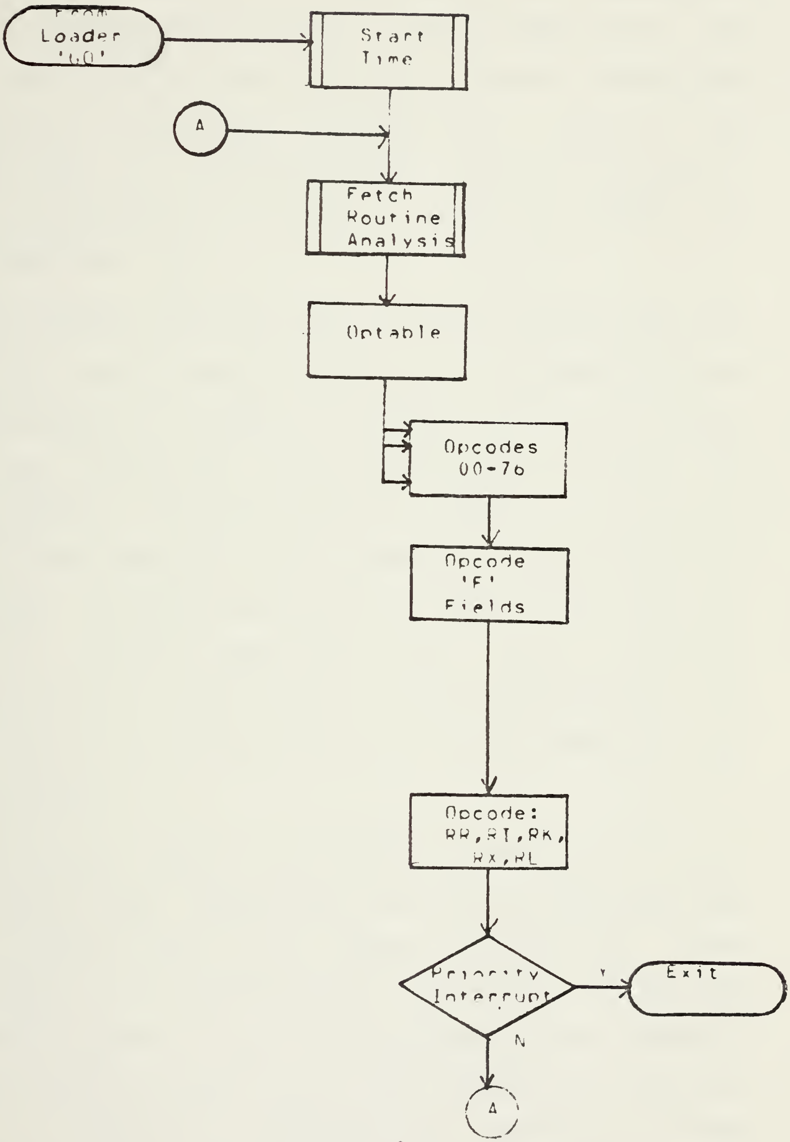


Figure V-8

The instruction fetch mode of OPCODE assumed that the PAR always pointed to an instruction word. Double-word instructions always had their 'y' field fetched after they were determined to be two words in length. Conditional double-word instructions performed their condition test before the 'y' field was fetched. If the test failed, the PAR was incremented by two prior to returning to OPCODE for continued execution.

The OPCODE routine was also written to accommodate the AN/UYK-20 'remote execute' instruction. When this operation was performed, a bit was set in the PSW which would indicate that one instruction out-of-line was being executed. For this operation, the current PSW was stored in memory, and the PAR was loaded with the address of the instruction to be executed. The OPCODE routine always checked the remote execute bit during an instruction cycle. If the bit was set, it would fetch the instruction indicated by the remote execute PAR, and restore the actual PAR, incremented by two, into the PSW.

Some of the opcode repertoire of the AN/UYK-20 was not emulated. Those instructions that were not emulated, however, retained slots in the opcode hierarchy for future inclusion. Any instruction not implemented by the emulator caused the machine to fault, and printed an error diagnostic on the selected output device ('NOT IMPLEMENTED - EXECUTION ENDS '). Similarly, locations were reserved for those instructions not assigned by the AN/UYK-20 were reserved

locations in the emulation . This permitted the emulator to be responsive to any future AN/UYK-20 hardware modifications. Whenever an instruction to be executed was not assigned, the emulator generated a fault interrupt and printed an error diagnostic on the selected output device ('FAULT INTERRUPT - EXECUTION ENDS').

E. UTILITIES

Although each emulated instruction performed different operations, each depended upon a common set of utility subroutines to accomplish their task. These subroutines varied in complexity, but each performed a function that contributed to successful instruction execution. A simple operation often required register addressing, condition code setting, and memory addressing, before the task was completed.

Utility subroutines were included in the emulation whenever feasible to simplify microprogramming and to alleviate programming redundancy. These subroutines were called using the successor command constructs available in TRANSLANG. Depending on the purpose of the utility routine, parameters were passed via D-machine register(s) or condition bit(s). This information was utilized by the utility in determining what operation was to be performed. In the carry subroutine, for example, a local condition bit was passed which indicated the appropriate condition code to be inserted into the PSW. A more complex example, the RX

format utility routine, required two parameters to be set by the instruction. Register A3 contained the instruction word and LC2 was set or cleared depending on whether or not byte formatting was required. The RX routine called other routines and could perform considerable processing before the final result, the effective operand address, was returned to the calling routine via the B register.

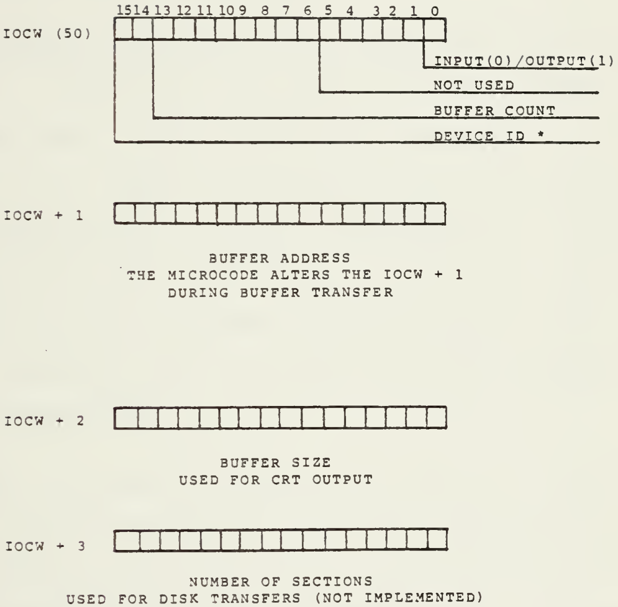
The utility section encompassed a number of routines which performed complex data manipulation. Arithmetic utilities for multiplication, division, and square root were accessed by nine separate AN/UYK-20 instructions. Indirection routines, which were called by the RX format routines, emulated the AN/UYK-20 cascaded addressing capabilities. A general purpose move subroutine permitted up to 256 cells of main memory to be moved from one location to another. This routine was used by the emulator's error diagnostic utilities, as well as the load and store multiple address register instructions.

F. INPUT/OUTPUT CONTROLLER

Although the AN/UYK-20's IOC was not emulated, several of its design features were imitated in creating a general purpose input/output controller for the emulator. The input/output command instruction (35 RR) initiated the I/O sequence, and reserved several cells in the memory mapping for I/O control words (Figure V-9). These control words contained fields which indicated what peripheral device was

AN/UYK-20 EMULATION

INPUT/OUTPUT COMMAND WORDS



* CODE: 00 - CRT
01 - PRT (OUTPUT)/CRD RDR (INPUT)
10 - DISK (NOT IMPLEMENTED)

Figure V-9

selected, the number of buffers that would be passed, whether input or output was desired, and where the buffer was located. Two additional words were reserved for control data required to interface with the disk and the CRT. The disk input/output microcode was not incorporated into the controller, but the framework was provided so the IOC could be readily inserted in the future.

The emulator's IOC section was located in the utility section of the emulation, and operated asynchronously with the Burroughs IOP. Since the IOC was collocated with the emulator in the same D-machine, it was not capable of independent processing. Once it was initiated, emulation execution waited until input/output was completed. The emulation had to use the Burroughs Common Language, since the IOP was microprogrammed to accept only this character set from other D-machines.

In order to transfer a 33-word line printer buffer to the IOP, the AN/UYK-20 emulator IOC had to use 66 AN/UYK-20 words. In order to send 20 words to the CRT, the IOC had to contruct a 40-word buffer. The COMPRES subroutine packed an AN/UYK-20 buffer of 66, 16-bit words into a 32-bit, 33-word buffer, suitable for output to the IOP.

Similarly, on input, a 20-word IOP buffer from the card reader or CRT expanded into a 40-word AN/UYK-20 buffer. In this case, the EXPAND subroutine split every packed 32-bit word of the IOP's buffer into two 16-bit words, suitable for processing by the emulator. These additional data transformations were required because of the buffering requirements of the Burroughs IOP.

VI. EMULATION TESTING

A. METHOD OF TESTING

The fundamental testing technique utilized throughout the development of the emulation consisted of three distinct phases: 1) each module was independently assembled and debugged until successful assembly was achieved, 2) each program segment was then tested for accuracy of the intended operation, and 3) the composite emulation program was tested under actual program conditions allowing for interaction among several modules. A debugging package, which was developed early in the emulation project, was the primary test vehicle for verifying emulation coding. Development and testing of the loader was, however, completed prior to the creation of the debugger.

Loader testing was accomplished by monitoring the control panel lights and synthetically halting program execution via the insertion of 'WAIT' statements, forcing the desired register to be transferred to 'MIR', and then re-examining the panel lights. This process was extremely tedious and time consuming but proved to be an invaluable tool for recognizing peculiar TRANSLANG constructs and microinstruction execution side effects.

Each module was subjected to an extensive desk checking process in order to reduce trivial assembly errors before running it on the machine. After a successful assembly had been achieved, the code was merged with previously existing assembled modules. The emulator was expanded as more modules were added, with utility routines being incorporated prior to the opcode programs.

Initially, the loader was designed, programmed, and thoroughly tested prior to the microprogramming of any AN/UYK-20 instructions or utilities. With the loader implemented, the emulation of the UYK-20 instruction repertoire could procede with a minimum of loader induced problems.

Independent opcodes and various utility routines were added to the previously assembled programs. The final emulation consisted of a total of 205 opcodes, a set of utility programs, and a workable loader.

In the next phase of testing, every module was subjected to a representative number of test cases which demonstrated how closely they compared to the documented AN/UYK-20 operation. Artificial environments were created to subject every opcode to a variety of situations. Whenever the operation of the opcode disagreed with the documented AN/UYK-20 operation, the opcode's function was thoroughly researched. The opcode's side effects were categorized and questions formulated. Often the answers could only be obtained from the Univac field engineer.

To illustrate the complexity of testing, an add instruction was tested with numerous operand combinations: two positive operands, two negative operands, one of each sign yielding a negative result, opposite signs producing a positive result, and opposite signs producing a zero sum. During each addition operation, the overflow, carry, and condition bits had to be monitored in status register 1 to verify their appropriate setting. This level of detail was achieved with all of the implemented opcodes in order to produce an efficient and accurate emulation.

Throughout the entire testing scenario, which composed 20% of the emulation project, the debugger routine (DUMPREG) provided the necessary information for examining opcode execution. A representative sample debugger output is provided in Appendix D.

DUMPREG permitted a snapshot of both AN/UYK-20 general register stacks, PSW, SR1, and SR2, in addition to the D-machine registers (A1, A2, A3, BR1, AMPCR, MIR) and the Burroughs external clock. DUMPREG possessed sufficient flexibility to be incorporated into the microcode at any point. In the final emulator, however, the debugger is user specified, and will dump the AN/UYK-20 emulator environment either at every instruction fetch and program stop, or when called by a loader control card.

B. SAMPLE TEST PROGRAMS

After subjecting the entire emulation to extensive testing, some representative test programs were developed to demonstrate the feasibility of the emulation and its capabilities and performance as compared to an actual AN/UYK-20. There were two programs which were selected because they incorporated numerous emulation features. The two programs were the solution of simultaneous linear equations by Cramer's rule and generation of prime numbers. It must be noted that streamlined program design was not emphasized but rather utilization of a variety of opcodes and features of the emulation.

The program for solving linear equations contained a total of 28 opcodes, requiring 28 opcode execution cycles and 43 instruction fetches. The program demonstrated all four fundamental mathematical operations, numerous store and load functions, a comparison test and a jump instruction. The capability of performing card reader input and output was added when the emulator IOC was completed.

The prime number program demonstrated 30 instructions which required 116 opcode execution cycles, and 122 instruction fetches. This program illustrated numerous comparison tests, looping structures, several jump instructions, a load multiple instruction, addition, and division. The test programs are included in Appendix E.

C. TEST RESULTS

The performance analysis of the test programs consisted primarily of running numerous test cases, examining the results for accuracy and computing the total time required to execute the emulated AN/UYK-20 programs. The timing of the programs was accomplished by using an external clock available on the ICP. The clock time provided a fairly close representation of the emulation execution time, but it cannot be considered a completely accurate measure since the emulation must interrogate the IOP to retrieve the external clock contents. Approximately 50 microseconds are used when sampling the clock.

The time requirements of the AN/UYK-20 program execution were hand-calculated by summing the published instruction execution times as presented in Ref. 21. The emulation performance ratio (EPR) was computed merely to give an approximate indication of the emulation performance. The EPR is the ratio of measured Burroughs emulation time to the calculated AN/UYK-20 execution time. Two EPR figures are recorded: one with paging implemented and one without. The paging EPR figure is significant only in that it indicates how much additional overhead must be incurred when emulating the paging mechanism of the AN/UYK-20. The required additional execution time was about 26%. Naturally, paging overhead is directly proportional to the number of instruction fetches or memory references performed during a program.

The results of program testing are as follows:

	CRAMER'S RULE	PRIME NUMBERS
Number of Opcodes	28	30
Number of Fetches	43	122
Execution Cycles	28	116
Time w/o paging	5000 usec	13000 usec
Time with Paging	8000 usec	17000 usec
AN/UYK-20 Time	78 usec	193 usec
EPR w/o Paging	64 :: 1	67 :: 1
EPR with Paging	103 :: 1	88 :: 1

These figures represent only approximate comparisons of the two machines. These computations provide an estimate of emulation characteristics. An effective EPR without paging was projected to be 65::1.

VII. SUMMARY AND RECOMMENDATIONS

A. EXPERIENCE WITH HARDWARE

The emulation project provided the unique opportunity of learning about two computer systems. The Burroughs D-machine demanded a detailed knowledge of hardware operation, as well as a thorough understanding of the microprogramming language, TRANSLANG. The computer architecture and processor capabilities of the AN/UYK-20 had to be investigated and then integrated into the control store memory of the Burrough's D-machine.

On several occasions, hardware malfunctions with the Burroughs equipment prevented normal system operation. The card reader was inoperable for several weeks, and the disk drive unit had to be repaired several times. During the final three weeks of project development, one D-machine ceased to function properly. This restricted emulation testing to the remaining D-machine.

Although these hardware difficulties impeded normal progress of the project, they did not prevent the emulation from successfully being completed. If a hardware problem prevented emulation testing or debugging, other modules were designed and testing was postponed. This permitted continual emulation development regardless of the hardware

status. In addition, considerable time and effort was invested in trouble-shooting hardware malfunctions, so they could be isolated, diagnosed, and repaired.

B. LESSONS LEARNED

The emulation project brought together many different computer science techniques and disciplines which will be useful in future computer science endeavors. A great deal of experience in both computer architecture and operation was gained in two different types of computers. Microprogramming provided new insight into computer design and revealed many potential applications for programmable control store machines.

Since emulations normally require a large development effort, this project had to incorporate judicious system design and project management principles in order for it to be completed successfully. Careful monitoring of critical stages of the emulation, and coordination of the programming effort to meet scheduled requirements, was necessary throughout this research. The small programming team concept proved to work extremely well in this project.

Finally, several software practices were strictly followed that proved to be invaluable in constructing the emulation. First, modular programming succeeded in partitioning the emulation into discrete modules which could be designed, coded, tested, and implemented individually. The

emulation was constructed in segments, using the previously verified modules as a test bed for the new modules being built. Structured programming and prolific documentation were useful in developing each microprogram routine because they permitted each team member to understand the function of the program and how it could be used.

C. EMULATION PROBLEMS

The most significant problem of the emulation was not having had any experience with an AN/UYK-20 and not having anyone readily available with prior AN/UYK-20 experience. This lack of knowledge created some anxiety when attempting to analyze the ramifications of individual opcodes.

The idiosyncrasies of certain opcodes were not made self-evident by the AN/UYK-20 software manuals. Consequently, numerous code modules were redesigned when more detailed information was provided by a UNIVAC field engineer. This proved to be very time consuming, inefficient, and frustrating.

Another emulation difficulty was the lack of working registers in the host machine as compared with the target machine. While the AN/UYK-20 has either 16 or 32 general registers, depending on whether the second stack option is incorporated, the D-machine has effectively only seven workable registers containing 16 bits or more. Therefore, all AN/UYK-20 registers had to be mapped into S-memory which

created much longer register read/write times. This created significant register manipulation problems which in some cases required main memory references for instructions intended to be strictly register-to-register operations. Consequently, increased execution times resulted in a higher emulation performance ratio (EPR), decreasing the overall emulation performance.

D. RESULTS

Emulating the AN/UYK-20 on a Burroughs D-machine required a considerable amount of preparation and planning before any results were realized. An in depth analysis of each computer's architecture and operating characteristics was conducted to insure that an emulation was feasible in the allotted time period. From the inception of the project, the goal of the emulation was to implement a standard AN/UYK-20 processor. This decision was based on the capability of the D-machine and an estimate of how much time would be involved in developing, debugging, and testing the final product. Although this goal was achieved, it was felt more time could have been devoted to testing and verifying emulation operation.

The AN/UYK-20 emulation was a highly complex microprogramming project involving numerous data structures and transfer protocols. A total of 205 AN/UYK-20 instructions were emulated out of nearly 290 instructions in the repertoire (including all IOC, math pac, and clock interrupt

opcodes). AN/UYK-20 diagnostic programs and user programs will establish the validity of the emulator's construction.

E. RECOMMENDATIONS AND FOLLOW-ON TOPICS

Although 205 opcodes have been implemented, tested, and developed into a working emulation, there are still many challenging avenues to pursue in creating the complete emulation package. First, testing is a continuous process and should be performed in conjunction with code optimization. A comprehensive code optimization effort could improve the EPR without sacrificing code readability.

Second, the floating point and 'math pac' options could be implemented. The addition of floating point arithmetic, trigonometric, and hyperbolic functions would significantly strengthen the scientific capabilities of the emulation. This would be an extremely strenuous undertaking but would permit more tactical data applications of the emulation, increasing its value to the Navy.

One area which could be examined is to perform a comprehensive timing analysis between an AN/UYK-20 and the emulation. This could consist of collecting numerous bench mark programs from Navy AN/UYK-20 installations, where performance data could be accurately obtained. These programs could then be run on the emulator, and analyzed with the bench mark results. The feasibility of replacing or substituting emulation host machines for target machines could be

addressed and supported by the timing analysis study.

An emulation of the AN/UYK-20 input/output controller could be incorporated into the emulation without serious difficulty. Since a second D-machine is available, the IOC channel processor instructions could be emulated and inserted into that D-machine's control memory. The independent processing characteristic of the AN/UYK-20 IOC would be fulfilled using this arrangement.

Finally, when the Burroughs system is linked with the computer science department's PDP 11/50, the AN/UYK-20 emulator could be connected to that system's peripheral resources. This would allow future incorporation of an AN/UYK-20 ULTRA assembler and a CMS-2M compiler into the PDP 11/50 system which could then produce machine language object code files for the AN/UYK-20 emulator to execute.

APPENDIX A. AN/UYK-20 EMULATOR USER'S MANUAL

This description is designed to provide sufficient information to operate the AN/UYK-20 emulation program. It is assumed that the informal Burroughs D-machine manual in the Burroughs laboratory will supply adequate power-on instructions and solve any hardware operating difficulties which may arise.

The procedure for utilizing the AN/UYK-20 emulator can be divided into four phases:

1) selection of the necessary loader control cards (JCL).
2) selection of the AN/UYK-20 program instruction set.
3) implementation of phases one and two into the required card or CRT format.
4) actual hardware implementation on the Burroughs D-machine resulting in program execution.

Phase one can be achieved by selecting the desired loader control cards described in Appendix B. The card format is identical to the CRT format, except that the CRT requires the user to <carriage return> at the end of every line of input data.

Phase two is accomplished by creating the AN/UYK-20 program from a subset of the 205 emulated instructions.

Phase three consists of keypunching the desired JCL and AN/UYK-20 program in the format illustrated in Appendix C.

The resulting job deck will typically be assembled as follows:

```
?SMLOAD TED/UYK20-OBJECT     % loads the emulator into
                               micromemory

L  00004                     % load the program into
                               page 4

C  00206 FAULT INTERRUPT-EXECUTION ENDS "

C  00214 NOT IMPLEMENTED-EXECUTION ENDS "

C  00222 DIVIDE OVERFLOW - FAULT ENTERED"

************************
other desired JCL
************************

AN/UYK-20 Program

    03,0,a,00                % priority interrupt
    (a = 00-17 octal)          (mandatory card)

G                            % commence program
                               execution

M (or M1)                    % machine status (reg. dump
                               at termination)

E                            % end job card
```

Finally, phase four consists of the entire program deck being loaded into the card reader. It is assumed that the IOP is at address 0015 hex, the selected interpreter is at address 0549 hex, the line printer is 'READY', and the IRQ switch is 'off'.

The IRQ switch is a three-way toggle switch mounted on the right side of the interpreter. In the up position, IRQ is 'on', horizontally it is 'off', and the downward position is used for external functions.

If either the interpreter or the IOP is not at the proper starting address, clear them by depressing the 'CLEAR' button on each unit. If this procedure does not remedy the situation, consult the user's manual in the laboratory.

Upon reading the ?SMLOAD card, the system will load the AN/UYK-20 emulator object program into the micromemory of the selected interpreter. The program address counter (on the interpreter) will be at the beginning of the emulation program, address 0000 hex. At this point, the user can select CRT input and output by placing the IRQ switch to the 'on' (upward) position. If CRT input is not desired, leave the IRQ switch in the 'off' (horizontal) position. Next, force step the interpreter by momentarily depressing the FST button (uppermost push button on side panel of the interpreter). Do not hold in the FST button. This may cause some undesirable side effects.

After depressing the FST button, the AN/UYK-20 program is loaded into S-memory. If the input is expected from the CRT, the user must enter his program from the console. Otherwise, the emulator will request cards from the card reader. Once the program has been loaded and the 'G' card read, program execution begins.

After successful program termination, the program returns to the loader and asks for more input. At this point, the user may terminate his job, or start another load sequence. It should be remembered that the AN/UYK-20 emulator has been designed for monoprogramming execution. It executes one program at a time, but can execute any number of programs in sequential order if desired. When the job is terminated, the D-machine returns to its starting address (0000 hex) and awaits further processing. When the user returns to the start address, the system is effectively 'master cleared' since S-memory will be cleared prior to executing any further jobs. It is not necessary, however, to use the ?SMLOAD card for additional programs or program re-runs because the emulator object code still resides in micromemory.

If the results of program execution are not as anticipated, use of either a 'T' or 'T1' option (trace card) is recommended to provide the user with a fetch-by-fetch program trace with the output to the printer or CRT respectively.

APPENDIX B. LOADER CONTROL CARD FORMATS

CARD COLUMNS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16 - 20
B	R W B		decimal			addr									
C			decimal			addr		character string followed by a "							
D			decimal			addr									data
E															
G			decimal			addr									
I	1 2					reg#									data
L			dec. page num												
M	1														
P															
R			dec. number												
S	1 2														
T	1														

Note: All numeric fields are in decimal.

LOADER CONTROL CARD DESCRIPTION

Control Card Identitifier		Description
B	---	The 'B' card is used to implement the breakpoint feature of the emulation. This features allows the user to specify a decimal address in columns 4-8. Column 2 must contain a R or W to breakpoint on a read or write operation respectively. The default condition is breakpoint on both read and write.
C	---	The 'C' card is used to insert character strings into memory. The character string starts in column 9 and continues until terminated by a quote symbol (") or the string reaches column 80. The decimal address where the character string will be written is given in columns 4-8. A blank or zero address field causes the character string to be inserted at the current load address.
D	---	The 'D' card is used to store decimal data from columns 16-20 into the memory address found in columns 4-8. A blank or zero address field causes the data to be inserted at the currrent load address.
E	---	The 'E' card is used to indicate the end-of-job and therefore is a mandatory control card for job separation.
G	---	The 'G' card or 'GO' card is used to start execution. The starting decimal address is in columns 4-8. The default value of a blank or zero address field will cause program execution to start address 01024.

I --- The 'I' card or set index register card is used to store decimal data from columns 16-20 into the register designated in columns 7-8, into the general register stack (1 or 2) specified in column 2.

L --- The 'L' or load card is used to partition memory into 256, 256-word (32-bit) pages and to load the program into the decimal page as referenced by columns 4-8. Pages 0-3 should not be used because they contain the required emulation register mapping and established workspace. The 'L' is a required control card, and it is recommended that it be the first JCL card.

M --- The 'M' card or machine status card provides a register dump, whereever it is inserted. It is normally placed between the 'G' and 'E' cards in the JCL deck. If a 1 is placed in column 2, the machine status dump will be sent to the CRT. This dump will contain the current value all AN/UYK-20 general registers, the PSW, SR2, next instruction address, the breakpoint address, and clocktime.

P --- The 'P' card is used to implement paging.

R --- The 'R' or reserve space card is used to reserve memory space as specified decimally in columns 4-8.

S --- The 'S' card is used to simulate setting of the program stop switches (1 and 2) on the AN/UYK-20 maintenance panel. Column 2 must contain a 1 or a 2. Two cards are required if both switches are to be set.

T --- The 'T' or trace card provides a fetch-by-fetch program trace, dumping the entire machine status on every fetch cycle. If a 1 is in column 2, the trace will be displayed on the CRT. This card is recommended for debugging programs.

APPENDIX C. AN/UYK-20 EMULATOR INSTRUCTION FORMAT

```
Format                        Card Columns
*********************************************************

                5  6  7  8  9  10  11  12  13  14

RR, RL,        opcode , 'f' ,   ' a '   ,   ' m '

RI Type 2


                5  6  7  8  9  10  11  12

RI Type 1      opcode , 'f' ,   '  d  '


                5  6  7  8  9  10  11  12  13  14  15  16 - 20

RK, RX         opcode , 'f' ,   '  a  ' ,   '  m  ' ,   ' y '
```

Notes:

1) All fields are in octal with the exceptions of addresses and the 'y' field which are decimal
2) All fields must be zero-filled
3) The following field restrictions must be followed:

Field	Range	Base
Opcode	00-76	octal
'f'	0-3	octal
'a'	00-17	octal
'm'	00-17	octal
'd'	000-377	octal
'y'	00000-65535	decimal
addr	00000-65535	decimal

APPENDIX D. SAMPLE DEBUGGER OUTPUT

This appendix provides a sample program output illustrating the Trace option. The debugger is called at the beginning of every instruction fetch, and at the termination of the program. Space has been provided for dumping 48 memory addresses including emulated AN/UYK-20 registers and D-machine registers. Each output line consists of eight regions printed in hexadecimal with a total of eight hex digits (32 bits) per region.

The listing is annotated to indicate the identity of each output cell. A summary of cell definitions (numbering from left to right, top to bottom) follows:

DECIMAL ADDRESS	DESCRIPTION
0 - 15	General Register Stack 1
16 - 31	General Register Stack 2
32	Program Status Word (PSW)
33	Breakpoint Register (BREAKPT)
34	Status Register 2 (SR2)
35	NEXTINSTR (next load address)
36	Clocktime
37	Real-Time Clock (RTC)
38	AMPCR
39	A1
40	A2
41	A3
42	MIR
43	BR1
44 - 47	Unused

```
      L  00004
      C  00236 FAULT INTERRUPT-EXECUTION ENDS '
      C  00214 NOT IMPLEMENTED-EXECUTION ENDS '
      C  00222 DIVIDE OVERFLOW - FAULT ENTERED'
      T                                  ENABLE DEBUGGER TRACE TO PRT
      P                                  ENABLE PAGING
      B  01025                           BREAKPOINT (R/W) AT ADDRESS 1025 DECIMAL
      I1    01       00015
      I1    02       00010
           02,0,02,01                    MAKE REG 2 NEGATIVE
           22,0,01,02                    ADD REG 2 TO REG 1 AND STORE RESULT IN REG 1
           03,0,00,00                    EXECUTIVE RETURN (HALT)
      G                                  COMMENCE EXECUTION
00000000  0000000F  0000000A  00000000  00000000  00000000  00000000  00000000
00000000  0000000C  00000000  00000000  00000000  00000000  00000000  00000000 (15)
00000000  0000000C  00000000  00000000  00000000  00000000  00000000  00000000
00000000  0000000D  00000000  00000000  00000000  00000000  00000000  00000000 (31)
00700400  00000401  80000000  00000403  00000000  00000000  0000063A  00700400 .
00000672  3030000C  00020000  00000002  00000000  00000000  00000000  00000000 (47)


00000000  0000000F  0000FFF6  00000000  00000000  00000000  00000000  00000000}
00000000  00000000  00000000  00000000  00000000  00000000  00000000  00000000}GEN REG STACK 1
00000000  00000000  00000000  00000000  00000000  00000000  00000000  00000000}
00000000  00000000  00000000  00000000  00000000  00000000  00000000  00000000}GEN REG STACK 2
00700400  00000401  80000000  00000403  00000000  00000000  0000063A  C1F0C401
00000672  00000821  0000FFF6  00000002  00000000  00000000  00000000  00000000


00000000  00000005  0000FFF6  00000000  00000000  00000000  00000000  00000000
00000000  00000000  00000000  00000000  00000000  00000000  00000000  00000000
00000000  00000000  00000000  00000000  00000000  00000000  00000000  00000000
00000000  00000000  00000000  00000000  00000000  00000000  00000000  00000000
00700400  00000401  80000000  00000403  00000000  00000000  0000063A  10F00402
00000672  00014812  00000005  00000002  00000000  00000000  00000000  00000000
PSW       BREAKPT   SR2       NEXTINSTR CLOCKTIME RTC       AMPCR     A1

00000404  00000005  0000FFF6  00000000  00000000  00000000  00000000  00000000
00000000  00000000  00000000  00000000  00000000  00000000  00000000  00000000
00000000  00000000  00000000  00000000  00000000  00000000  00000000  00000000
00000000  0000000C  00000000  00000000  00000000  00000000  00000000  00000000
00700400  00000401  8000000C  00000403  00003F2C  00000000  000005E4  10F00403
00000000  00000000  00003E2C  00000002  00000000  00000000  00000000  00000000
A2        A3        MIR       BRI       [<------------- 44 - 47 ------------->]

      E                                  END OF JOB
```

APPENDIX E. SAMPLE TEST PROGRAMS

The programs listed in this appendix were designed to illustrate how the AN/UYK-20 emulator can be used for developing programs. The first two programs presented are the generation of prime numbers and the solution of simultaneous linear equations by Cramer's Rule. They depict several AN/UYK-20 control structures such as looping, iteration, and condition code testing as well as numerous load, store, and arithmetic operations. The last program performs the Cramer's Rule algorithm and demonstrates input/output routines.

```
L   00034                        PRIME NUMBER GENERATOR
I1                               PRIME NUMBERS RETURNED IN GEN. REGISTERS
P                                THIS CARD WILL ENVOKE PAGING
C   00206 FAULT INTERRUPT-EXECUTION ENDS '
C   00214 NOT IMPLEMENTED-EXECUTION ENDS '
C   00222 DIVIDE OVERFLOW - FAULT ENTERED'
     63,0,04,01                  LITERAL LOAD, 1 INTO REG 4 (1ST PRIME)
     63,0,05,02                  LITERAL LOAD, 2 INTO REG 5 (2ND PRIME)
     63,0,06,02                  LITERAL LOAD, 2 INTO REG 6 (COUNTER)
     63,0,07,05                  LITERAL LOAD, NO. OF PRIMES INTO REG 7
     11,3,04,00,02048            STORE  A 1 INTO ADDR 2048
     11,3,05,00,02049            STORE  A 2 INTO ADDR 2049
     24,0,07,04                  COMPARE N (NO. OF PRIMES) & 1
     44,1,026                    LOCAL JUMP, IF EQUAL
     24,0,07,05                  COMPARE N AND 2
     44,1,023                    LOCAL JUMP, IF EQUAL
     63,0,11,02                  LITERAL LOAD, 2 INTO REG 11 (CANDIDATE)
     62,2,11,01                  LITERAL ADD, INCREMENT CANDIDATE
     63,0,10,02                  LITERAL LOAD, 2 INTO REG 10 (TRIAL DIVIS)
     01,0,13,11                  LOAD REG, CANDIDATE INTO REG 13
     01,0,12,00                  LOAD REG 12 WITH 0
     27,0,12,10                  DIVIDE REG, CANDIDATE BY TRIAL DIVISOR
     24,0,00,12                  COMPARE, REMAINDER WITH 0
     44,1,371                    JUMP IF EQUAL, NON-PRIME, GET NEXT CAND.
     62,2,10,01                  LITERAL ADD, INCREMENT TRIAL DIVISOR
     24,0,10,11                  COMPARE DIVISOR WITH CANDIDATE
     47,1,370                    JUMP IF LESS THAN, TRY NEW DIVISOR
     11,3,11,06,02048            STORE FOUND PRIME INTO MEMORY
     62,2,06,01                  LITERAL ADD, INCREMENT PRIME COUNTER
     24,0,06,07                  COMPARE, PRIME COUNTER WITH N
     47,1,351                    JUMP IF LESS THAN, GET NEXT PRIME CAND.
     03,3,00,04,02048            LOAD MULT, PRIMES FROM MEMORY INTO REGS
     03,0,17,00                  PRIORITY INTERRUPT, HALT EXECUTION
     63,0,01,02                  LIT LOAD, FORCE FEED 2 INTO REG 01
     63,0,00,01                  LIT LOAD, FORCE FEED 1 INTO REG 00
     03,0,17,00                  PRIORITY INTERRUPT, HALT EXECUTION
G                                GO, COMMENCE EXCUTION
M                                MACHINE STATUS TO THE PRINTER
00000001  00000002  00000003  00000005  00000007  00000002  00000005  00000005
00000007  00000007  00000001  00000001  00000000  00000000  00000000  00000420
00000000  00000000  00000000  00000000  00000000  00000000  00000000  00000000
0000000C  00000000  00000000  00000000  00000000  00000000  00000000  00000000
00400400  00000000  00000000  00000422  00000018  00000000  0000C161  0000000C
00000030  000000F0  00000000  00000005  00000000  0000000C  00000000  00000000

E                                END OF JOB
```

```
L  C0004                          LINEAR EQUATIONS BY CRAMER:S RULE.
T1                                X IS RETURNED IN REG 01, Y IN REG 05
C  00206 FAULT INTERRUPT-EXECUTION ENDS '
C  00214 NOT IMPLEMENTED-EXECUTION ENDS '
C  00222 DIVIDE OVERFLOW - FAULT ENTERED'
D  02048        00030             BOTH EQUATIONS MUST BE IN STD FORM
D  02049        00030             A (Y) PLUS B (X) EQUALS C
D  02050        00003             Y COEFF OF 1ST EQN
D  02051        65531             X COEFF OF 1ST EQN
D  02052        00019             CONSTANT OF 1ST EQN
D  02053        00002             Y COEFF OF 2ND EQN
D  02054        65532             X COEFF OF 2ND EQN
D  02055        00016             CONSTANT OF 2ND EQN
     01,3,01,00,02050             STORE X COEFF, EQN 1, INTO REG 01
     01,3,03,00,02051             STORE Y COEFF, EQN 1, INTO REG 03
     01,3,05,00,02052             STORE CONSTANT, EQN 1, INTO REG 05
     01,3,11,00,02053             STORE Y COEFF, EQN 2, INTO REG 11
     01,3,13,00,02054             STORE X COEFF, EQN 2, INTO REG 13
     01,3,15,00,02055             STORE CONSTANT, EQN 2, INTO REG 15
     26,0,00,13                   MULT LEFT DIAG OF DENOM, RESULT IN 00/01
     26,0,10,03                   MULT RT. DIAG OF DENOM, RESULT IN 10/11
     21,0,00,10                   SUBTRACT DOUBLE, RESULT OF DENOM IN 00/01
     25,3,00,17,02048             COMPARE DENOM WITH ZERO
     44,1,052                     JUMP, IF EQUAL (ZERO DETERMINANT)
     12,3,00,06,00014             STORE DOUBLE, DENOM INTO 16/17
     01,2,00,00,00030             LOAD 00 INTO REG 00
     01,3,01,00,02050             RESTORE Y COEFF, EQN 1, INTO REG 01
     01,3,03,00,02051             RESTORE X COEFF, EQN 1, INTO REG 03
     01,3,05,00,02052             RESTORE CONSTANT OF EQN 1 IN REG 05
     01,3,11,00,02053             RESTORE Y COEFF OF EQN 2 IN REG 11
     01,3,13,00,02054             RESTORE X COEFF OF EQN 2 IN REG 13
     01,3,15,00,02055             RESTORE CONSTANT OF EQN 2 IN REG 15
     26,0,00,15                   X NUM LEFT DIAG MULT, RESULT IN 00/01
     26,0,10,05                   X NUM RT. DIAG MULT, RESULT IN 10/11
     21,0,00,10                   X NUM RESULT IN REG 00/01
     27,0,00,17                   X RESIDES IN REG 01
     26,0,04,13                   Y NUM LEFT DIAG MULT, RESULT REG 04/05
     26,0,14,03                   Y NUM RT. DIAG MULT, RESULT REG 14/15
     21,0,04,14                   DOUBLE SUBTRACT (EVAL NUM), RESULT 04/05
     27,0,04,17                   DIVIDE NUM/DENOM, Y RESIDES IN 05
     03,0,17,00                   PRIORITY INTERRUPT, HALT EXECUTION
G                                 GO, COMMENCE EXECUTION
M                                 MACHINE STATUS TO THE PRINTER
00000000  0000FFFB  00000000  0000FFFB  00000000  0000FFFE  00000000  00000000
00000000  00000026  00000000  0000FFFC  0000FFFF  0000FF80  0000FFFF  0000042C
00000000  00000000  00000000  00000000  00000000  00000000  00000000  00000000
00000000  00000000  00000000  00000000  00000000  00000000  00000000  00000000
00000400  00000000  00000000  00000428  00000005  00000000  00000161  00000000
00000030  00000050  00000000  00000004  00000000  0000000C  00000000  00000000

F                                 END OF JOB
```

```
P                         ****LINEAR EQUATIONS BY CRAMER:S RULE.****
L  00034
C  00236 FAULT INTERRUPT-EXECUTION ENDS '
C  00214 NOT IMPLEMENTED-EXECUTION ENDS '
C  00222 DIVIDE OVERFLOW - FAULT ENTERED'
I2    30       17654         IOCW FOR 20 BUFFERS FROM CARD READER
I2    31       04036
I2    32       16758         IOCW FOR 6 BUFFERS FROM CARD READER
I2    03       05120
I2    04       16735         OUTPUT IOCW FOP 5 BUFFERS TO PRT
I2    05       08036
I2    36       17655         OUTPUT 20 BUFFERS TO PRT
I2    37       10240
I2    08       12336         REGISTER CONTAINING TWO BCL SPACE CHARACTERS
I2    11       00040
I2    15       00050
D  02048       00030         BOTH EQUATIONS MUST BE IN STD FORM
D  02049       00030         A (Y) PLUS B (X) EQUALS C
D  02050       00031         Y COEFF OF 1ST EQN
D  02051       00031         X COEFF OF 1ST EQN
D  02052       00033         CONSTANT OF 1ST EQN
D  02053       00031         Y COEFF OF 2ND EQN
D  02054       65535         X COEFF OF 2ND EQN
D  02055       65535         CONSTANT OF 2ND EQN
   63,0,13,01                LOAD 1 INTO REG. 13
   03,0,13,05                LOAD SR1 WITH REG 13
   12,1,00,17                STORE DOUBLE INTO IOCW
   35,0,03,00                INPUT 14 BUFFERS FROM CARD READER
   12,1,02,17                STORE DOUBLE INTO IOCW
   35,0,03,00                INPUT 6 BUFFERS FROM THE CARD READER
   01,2,12,00,01320          INITIALIZE BUFFER WORDS COUNT (20 PRT BUFFERS)
   01,2,11,00,10240          INITIALIZE OUTPUT BUFFER ADDR
   15,1,10,11                STORE (RA) INTO Y* AND INDEX BY 1 (STORE SPACES)
   02,0,12,11                DECREMENT BUFFER COUNTER
   45,1,375                  COUNTER EQUAL ZERO
   01,2,14,00,04036          INITIALIZE BUFFER ADDRESS OF INPUT
   01,2,15,00,00020          BUFFER COUNT
   01,2,11,00,10240          INTIALIZE DESTINATION BUFFER ADDR
   05,1,15,14                LOAD AND INDEX BY 1
   15,1,15,11                STORE RA INTO Y* AND INDEX Y*
   02,0,13,11                DECREMENT COUNTER
   45,1,374                  COUNTER EQUAL ZERO
   22,2,11,00,00026          ADD 26 TO BUFFER ADDR
   01,2,13,00,00040          RESET  BUFFER WORD COUNT
   02,0,13,11                DECREMENT NEXT COUNTER (NO. OF BUFFERS)
   45,1,356                  COUNTER EQUAL ZERO
   12,1,05,17                STORE DOUDLE INTO IOCW
   35,0,03,00                OUTPUT 14 BUFFERS TO PRT
```

```
63,0,15,01                ***RE-ENTRY POINT FOR REPETITIVE EXECUTION***
03,0,15,05                   LOAD SR1 WITH A 1 FROM REG 13
01,2,11,00,08096             INITIALIZE NEXT OUTPUT BUFFER ADDRESS
01,2,12,00,00330             INITIALIZE NEXT BUFFER WORD COUNT (5 PRT BUFFERS)
01,2,13,00,00005             BUFFER COUNT
01,2,14,00,05120             INITIALIZE  BUFFER ADDR OF SECOND INPUT BUFFER
15,1,10,11                   STORE (RA) INTO Y* AND INDEX BY 1 (STORE SPACES)
02,0,12,11                   DECREMENT BUFFER COUNTER
45,1,375                     COUNTER EQUAL ZERO
01,2,11,00,08096             REINITIALIZE BUFFER ADDR IN REG 9
05,1,15,14                   LOAD AND INDEX BY 1
15,1,15,11                   STORE RA INTO Y* AND INDEX Y*
02,0,13,11                   DECREMENT COUNTER
45,1,374                     COUNTER EQUAL ZERO
22,2,11,00,00026             ADD 26 TO BUFFER ADDR
01,2,13,00,00040             RESET  BUFFER WORD COUNT
02,0,15,11                   DECREMENT NEXT COUNTER (NO. OF BUFFERS)
45,1,356                     COUNTER EQUAL ZERO
63,0,15,00                   LOAD REG 13 WITH 0
03,0,15,05                   LOAD SR1 WITH 0
01,3,01,00,02050          ***CRAMER'S RULE ALGORITHM***  STORE X OF EQN 1
01,3,03,00,02051             STORE Y COEFF, EQN 1, INTO REG 03
01,3,05,00,02052             STORE CONSTANT, EQN 1, INTO REG 05
01,3,11,00,02053             STORE Y COEFF, EQN 2, INTO REG 11
01,3,13,00,02054             STORE X COEFF, EQN 2, INTO REG 13
01,3,15,00,02055             STORE CONSTANT, EQN 2, INTO REG 15
26,0,00,13                   MULT LEFT DIAG OF DENOM, RESULT IN 00/01
26,0,10,03                   MULT RT.  DIAG OF DENOM, RESULT IN 10/11
21,0,00,10                   SUBTRACT DOUBLE, RESULT OF DENOM IN 00/01
25,3,00,17,02048             COMPARE DENOM WITH ZERO
44,1,052                     JUMP, IF EQUAL (ZERO DETERMINANT)
12,3,00,06,00014             STORE DOUBLE, DENOM INTO 16/17
01,2,00,00,00000             LOAD 00 INTO REG 00
01,3,01,00,02050             RESTORE Y COEFF, EQN 1, INTO REG 01
01,3,03,00,02051             RESTORE X COEFF, EQN 1, INTO REG 03
01,3,05,00,02052             RESTORE CONSTANT OF EQN 1 IN REG 05
01,3,11,00,02053             RESTORE Y COEFF OF EQN 2 IN REG 11
01,3,13,00,02054             RESTORE X COEFF OF EQN 2 IN REG 13
01,3,15,00,02055             RESTORE CONSTANT OF EQN 2 IN REG 15
26,0,00,15                   X NUM LEFT DIAG MULT, RESULT IN 00/01
26,0,10,05                   X NUM RT.  DIAG MULT, RESULT IN 10/11
21,0,00,10                   X NUM RESULT IN REG 00/01
27,0,00,17                   X RESIDES IN REG 01
26,0,04,13                   Y NUM LEFT DIAG MULT, RESULT REG 04/05
26,0,14,03                   Y NUM RT.  DIAG MULT, RESULT REG 14/15
21,0,04,14                   DOUBLE SUBTRACT (EVAL NUM), RESULT 04/05
27,0,04,17                   DIVIDE NUM/DENOM, Y RESIDES IN 05
```

```
01,2,07,00,16339        ***INT TO BCL CONVERSION*** TWICE BUFFER ADDR PLUS 1
63,0,03,00                 LIT LOAD, C INTO REG 0
63,3,00,12                 LIT DIVIDE, REG 0/1 BY 10
10,3,03,07,00030           BYTE STORE, REG 7 MUST CONTAIN TWICE ADDR
44,1,033                   LOCAL JUMP EQUAL (ZERO QUOTIENT)
63,0,03,00                 LIT LOAD, C INTO REG 0
62,0,07,01                 LIT SUBTRACT, 1 FROM REG 7
40,1,371                   LOCAL JUMP
01,2,07,00,16633           LOAD CONSTANT, TWICE ADDR PLUS 1 IN REG. 7
63,0,04,00                 LIT LOAD, C INTO REG 4
63,3,04,12                 LIT DIVIDE, REG 4/5 BY 10
10,3,04,07,00030           BYTE JUMP
44,1,033                   JUMP EQUAL, CHECK FOR ZERO QUOTIENT
63,0,04,00                 LIT LOAD, 0 INTO REG 4
62,0,07,01                 LIT SUBTRACT, 1 FROM REG 7
40,1,371                   LOCAL JUMP
63,0,15,01                 LOAD REG 13 WITH A 1
03,0,15,05                 LOAD SR1 WITH A 1
12,1,04,17                 STORE DOUBLE INTO IOCW
35,0,03,00                 DUMP 5 BUFFERS TO PRT
03,0,05,00                 HALT
63,0,15,01              ***NO SOLUTION CASE***
03,0,15,05                 LOAD SR1 WITH A 1
20,2,11,00,00178           RECOMPUTE OUTPUT BUFFER ADDR FOR 'NO SOLUTION'
01,2,13,00,00040           REINITIALIZE COUNTER
05,1,15,14                 LOAD AND INDEX BY 1
15,1,15,11                 STORE RA INTO Y* AND INDEX Y*
02,0,13,11                 DECREMENT COUNTER
45,1,374                   COUNTER EQUAL ZERO
12,1,04,17                 STORE DOUBLE INTO IOCW
35,0,03,00                 DUMP 5 BUFFERS TO PRT
03,0,05,00                 HALT
```

```
        G                              COMMENCE EXECUTION

THIS IS A DEMONSTRATION PROGRAM OF THE AN/UYK20 EMULATOR.
THE PROGRAM SOLVES TWO SIMULTANEOUS EQUATIONS BY CRAMER'S RULE.

THE INPUT COEFFICIENT VALUES AND CONSTANTS FOR EACH EQUATION MUST BE INSERTED
USING LOADER CONTROL CARDS IN THE FOLLOWING LOCATIONS

1ST EQUATION.   A1 IN LOCATION 2050 D.
                B1 IN LOCATION 2051 D.
                CONSTANT IN LOCATION 2052 D.

2ND EQUATION.   A2 IN LOCATION 2053 D.
                B2 IN LOCATION 2054 D.
                CONSTANT IN LOCATION 2055 D.


     THE RESULT IS.
     X >       2

     Y >       1
TO CHANGE VARIABLES INSERT LOADER JCL HERE, OTHERWISE EXIT
        I2    L1       00040          REINITIALIZE BUFFER WORD COUNT FOR BUFFER INIT.
        D  02053       00001          Y COEFF OF 2ND EQUATION
        D  02054       00001          X COEFF OF 2ND EQUATION
        D  02055       00003          CONSTANT OF 2ND EQUATION
        G  00031                      RE-EXECUTE PROGRAM AT ADDR 1055 DECIMAL
     THE RESULT IS.
     X >
        NO SOLUTION
     Y >
TO CHANGE VARIABLES INSERT LOADER JCL HERE, OTHERWISE EXIT
        E                             END EXECUTION
```

APPENDIX F. EMULATOR LISTING

This appendix provides a listing of the TRANSLANG assembler output of the AN/UYK-20 emulation. A source file copy of the emulator exists on disk as well as on cards. A microinstruction object file is also maintained on disk.

The listing is divided into four sections. The left most section contains the microinstruction address composed of four hexadecimal digits followed by a 56-bit microinstruction created from a TRANSLANG instruction. The center section contains the TRANSLANG source which includes labels, an instruction, and/or a comment field. The final number printed on the right most side of the listing is the sequence number of the TRANSLANG source statement. This number, printed in decimal, is created by a Burroughs software utility program called CARD-LIST. This number must be used when editing source programs on disk.

```
                                   $MERGE TED/UYK20
                                   PROGRAM TED/UYK20-OBJECT
                                   * * * * * * * * * * * * * * MAIN MEMORY ADDRESS MAPPING * * * * * * * * *
                                                                   *
                                   GREG1 * 0                       * ADDRESS OF GENERAL REGISTER STACK ONE
                                   GREG2 * 16                      * ADDRESS OF GENERAL REGISTER STACK TWO
                                   PSW * 32                        * PROGRAM STATUS WORD (PAR & SR #1)
                                   BKPT * 33                       * BREAKPOINT REGISTER
                                   STATUS2 * 34                    * STATUS REGISTER TWO
                                   NXTINSTR * 35                   * ADDRESS OF NEXT INSTRUCTION
                                   CLOCKTIME * 36                  * TIME OF EXECUTION
                                   RTC * 37                        * REAL TIME CLOCK
                                   WORKSPACE * 38                  * TEMPORARY STORAGE STACK
                                   STACK * 44                      * TEMPORARY STORAGE STACK
                                   IOCW * 50                       * INPUT OUTPUT COMMAND WORDS (THRU 53)
                                   HEXADDR * 120                   * HEX ADDR TO BE PRINTED (TWO WORD VAL)
                                                                   *
                                                                   * CARDBUFFER ADDRESSES
                                                                   *
                                   CARDBUF * 122                   * ADDRESS OF CARD BUFFER
                                   CARD1X4 * 122                   * ADDRESS OF CARD COLS 1-4
                                   CARD5X8 * 123                   * ADDRESS OF CARD COLS 5-8
                                   CARD9X12 * 124                  * ADDRESS OF CARD COLS 9-12
                                   CARD13X16 * 125                 * ADDRESS OF CARD COLS 13-16
                                   CARD77X80 * 141                 * ADDRESS OF CARD COLS 77-80. END OF CARD
                                                                   *
                                   PRINTBUFF * 153                 * PRINT BUFFER LOCATION
                                                                   *
                                   CRTBUFF * 186                   * CRT BUFFER (20 WORDS)
                                                                   *
                                   ERRORLIST * 206                 * LIST OF POSSIBLE ERRORS
                                   PAGEREG * 768                   * PAGE ADDRESS REGISTERS STACK BASE
                                                                   * (0-255)
                                                                   *
                                   * * * * * * * * * * * * * * * LOADER * * * * * * * * * * * * * * * * * *
                                                                   *
                                                                   * BEGIN PROGRAM BY ZEROING MAIN MEMORY
                                   START:                          * RESTART RETURN POINT
                                                                   * IF CRT INPUT DESIRED, PUT IRO SW ON
0C00  4800 C000 0C30 C0F0                WAIT                      * TOGGLE EXECUTION BY SINGLE STEP
0C01  0088 00C1 401C 00F0                SET GC1; WHEN GC1 THEN 1 L = A1,MAR2
0C02  0000 0000 0030 C020                COMP 16 = SAR
0C03  4812 00C0 0C30 00F0                0 = MIR; SAVE
0C04  9809 ACDE 400C 1CF0                MW2; A1 -1 = A1; IF SAI
0C05  6819 0000 0000 C0FC                IF ABT THEN SKIP ELSE STEP  * WHEN A1 = ZERO 64K OF MEMORY = 0
0C06  9C28 A0C0 001C 00FC                WHEN SAI THEN A1 = MAR2; JUMP
0C07  0000 0000 0000 C040                NEWCARD - 1 = MPCR        * FETCH A CARD
                                                                   *
                                                                   *
                                                                   *
                                   CONTROLCD:                      * THIS ROUTINE WILL READ COLUMNS 1-4 AND
                                                                   * EXAMINE COLUMN 1 FOR A CONTROL CARD
                                                                   * IDENTIFIER.  IF THE CARD IS A CONTROL
                                                                   * THE APPROPRIATE ROUTINE WILL BE CALLED.
0C08  4809 200C 0C1C C0F0                LIT = MAR2                * LOAD ADDRESS OF CARD COLUMNS 1-4.
0C09  07AC 00C0 0000 C0EC                CARD1X4 = LIT
0C0A  C010 00C0 0C00 0060                INPUT - 1 = CPCR          * READ COLUMNS 1-4
0C0B  4809 20C1 C030 40F0                LIT C = A1,CSAR           * LOAD MSB OF A1 WITH 00111111
```

```
0C0C   03FC 0000 0000 0090          63 = LIT; B = SAR                                              00058000 D
0C0D   4809 AC56 8B0C C0F0          A1 AND B R = B            % FILL LSB OF B REGISTER WITH CHARACTER 00059000 D
                                                              % FROM COLUMN ONE.                      00060000 D
                                                              %                                       00061000 D
0C0E   4809 2C52 0000 00F0          LIT EQL B                                                         00062000 D
0C0F   0120 0000 0000 00E0          18 = LIT                  % BCL CODE FOR "B"                      00063000 D
0C10   680B 2C52 0000 C0F0          LIT EQL B; IF TRUE THEN STEP ELSE SKIP  % CHECK FOR "B"           00064000 D
0C11   0020 0000 0000 C040          BREAKPOINT - 1 = MPCR %  JUMP TO BREAKPOINT ROUTINE               00065000 D
                                                              %                                       00066000 D
0C12   0190 0000 0000 00E0          20 = LIT                  % BCL CODE FOR "D"                      00067000 D
0C13   680B 2C52 0000 00F0          LIT EQL B; IF TRUE THEN STEP ELSE SKIP  % CHECK FOR "D"           00068000 D
0C14   0030 0000 0000 C040          DATA - 1 = MPCR           % JUMP TO DATA ROUTINE                  00069000 D
                                                              %                                       00070000 D
0C15   0150 0000 0000 00E0          21 = LIT                  % BCL CODE FOR "E"                      00071000 D
0C16   680B 2C52 0000 C0F0          LIT EQL B; IF TRUE THEN STEP ELSE SKIP  % CHECK FOR "E"           00072000 D
0C17   FFFC 0000 0000 0050          START - 1 = MPCR          % JOB TERMINATION. REINITIALIZE MEMORY  00073000 D
                                                              %                                       00074000 D
0C18   0170 0000 0000 00E0          23 = LIT                  % BCL CODE FOR "G"                      00075000 D
0C19   580B 2C52 0000 00F0          LIT EQL B; IF TRUE THEN STEP ELSE SKIP  % CHECK FOR "G"           00076000 D
0C1A   0040 0000 0000 0040          GO - 1 = MPCR             % JUMP TO GO ROUTINE                    00077000 D
                                                              %                                       00078000 D
0C1B   0190 0000 0000 C0E0          25 = LIT                  % BCL CODE FOR "I"                      00079000 D
0C1C   680B 2C52 0000 00F0          LIT EQL B; IF TRUE THEN STEP ELSE SKIP  % CHECK FOR "I"           00080000 D
0C1D   0050 0000 0000 C040          SETINDEXREG - 1 = MPCR  % JUMP TO THE SET INDEX REG ROUTINE       00081000 D
                                                              %                                       00082000 D
0C1E   0230 0000 0000 00E0          35 = LIT                  % BCL CODE FOR "L"                      00083000 D
0C1F   680B 2C52 0000 C0F0          LIT EQL B; IF TRUE THEN STEP ELSE SKIP   % CHECK FOR "L"          00084000 D
0C20   0060 0000 0000 0040          LOAD - 1 = MPCR           % JUMP TO LOAD ROUTINE                  00085000 D
                                                              %                                       00086000 D
                                                              %                                       00087000 D
0C21   0270 0000 0000 00E0          39 = LIT                  % BCL CODE FOR "P"                      00088000 D
0C22   680B 2C52 0000 00F0          LIT EQL B; IF TRUE THEN STEP ELSE SKIP  % CHECK FOR "P"           00089000 D
0C23   0070 0000 0000 0040          SETPAGING - 1 = MPCR  % JUMP TO SET PAGING BIT ROUTINE            00090000 D
                                                              %                                       00091000 D
0C24   0290 0000 0000 00E0          41 = LIT                  % BCL CODE FOR "R"                      00092000 D
0C25   680B 2C52 0000 C0F0          LIT EQL B; IF TRUE THEN STEP ELSE SKIP  % CHECK FOR "R"           00093000 D
0C26   0080 0000 0000 0040          RESERVESPACE - 1 = MPCR  % JUMP TO RESERVESPACE ROUTINE           00094000 D
                                                              %                                       00095000 D
0C27   0320 0000 0000 00E0          50 = LIT                  % BCL CODE FOR "S"                      00096000 D
0C28   680B 2C52 0000 C0F0          LIT EQL B; IF TRUE THEN STEP ELSE SKIP  % CHECK FOR "S"           00097000 D
0C29   0090 0000 0000 C040          SWITCHES - 1 = MPCR       % JUMP TO SWITCHES ROUTINE              00098000 D
                                                              %                                       00099000 D
0C2A   0330 0000 0000 00E0          51 = LIT                  % BCL CODE FOR "T"                      00100000 D
0C2B   680B 2C52 0000 00F0          LIT EQL B; IF TRUE THEN STEP ELSE SKIP  % CHECK FOR "T"           00101000 D
0C2C   00A0 0000 0000 0040          TRACE - 1 = MPCR          % JUMP TO TRACE ROUTINE                 00102000 D
                                                              %                                       00103000 D
0C2D   0130 0000 0000 C0E0          19 = LIT                  % BCL CODE FOR "C"                      00104000 D
0C2E   680B 2C52 0000 00F0          LIT EQL B; IF TRUE THEN STEP ELSE SKIP  % CHECK FOR "C"           00105000 D
0C2F   00B0 0000 0000 C040          CHARSTRING - 1 = MPCR  % JUMP TO CHARACTER STRING ROUTINE         00106000 D
                                                              %                                       00107000 D
0C30   0300 0000 0000 C0EC          48 = LIT                  % BCL CODE FOR BLANK                    00108000 D
0C31   680B 2C52 0000 C0F0          LIT EQL B; IF TRUE THEN STEP ELSE SKIP  % CHECK FOR BLANK         00109000 D
0C32   00C0 0000 0000 C040          INSTRUCTION - 1 = MPCR  % JUMP TO THE INSTRUCTION HANDLING SUBR00110000 D
                                                              %                                       00111000 D
0C33   0240 0000 0000 00E0          36 = LIT                  % BCL CODE FOR "M"                      00112000 D
0C34   680B 2C52 0000 C0F0          LIT EQL B; IF TRUE THEN STEP ELSE SKIP  % CHECK FOR "M"           00113000 D
0C35   0000 0000 0000 0040          MACHSTAT - 1 = MPCR       % JUMP TO MACHINE STATUS ROUTINE        00114000 D
                                                              %                                       00115000 D
0C36   00E0 0000 0000 C040          NEWCARD - 1 = MPCR        % DEFAULT. GET NEW CARD                 00116000 D
                                                              %                                       00117000 D
```

```
                              LOAD:                            * SET UP MEMORY INTO 256 PAGES OF 256      00118000 D
                                                               * WORDS (32 BIT) EACH.  THE PAGE NO. IN    00119000 D
                                                               * THE "L" CARD (COL. 5-8) WILL BE          00120000 D
                                                               * TRANSLATED INTO  THE BASE ADDRESS OF     00121000 D
                                                               * THE SELECTED PAGE AND STORED IN          00122000 D
                                                               * THE NEXTINST REG TO BE UTILIZED AS THE   00123000 D
                                                               * BASE ADDRESS TO LOAD THE PROGRAM.        00124000 D
0037  4809 0000 0B90 00FC          0 = B,MIR                   * ZERO B AND MIR                           00125000 D
0038  4809 0640 001C 00F0          AMPCR = MAR2                *SET UP ADDRESS OF PAGE REGISTER           00126000 D
0039  3000 0000 0000 00C0          PAGEREG = AMPCR                                                        00127000 D
003A  0FE0 0000 0000 00E0          254 = LIT                   * SET UP CTR FOR 255 + 1 ITERATIONS        00128000 D
003B  4812 0000 0C01 00F0          LCTR; SAVE                  * THIS LOOP WILL INITIALIZE 256 PAGE ADDR00129000 D
                                                               * REGISTERS TO THEIR BASE ADDRESSES.       00130000 D
003C  9809 0000 0000 1CF0          MW2; BMI; IF SAI            * TRANSFER MIR TO B AFTER MEMORY WRITE     00131000 D
003D  9008 0046 0092 00F0          WHEN SAI THEN B + 1 = MIR,INC * INCREMENT PAGE NO. TO BE LOADED00132000 D
                                                               * INTO THE NEXT PAGE ADDRESS               00133000 D
                                                               * AND INCREMENT LOOP COUNTER               00134000 D
003E  8429 0F46 001C 00FC          IF NOT COV THEN BMAR + 1 = MAR2; JUMP  * INCREMENT ADDR OF PAGE00135000 D
003F  4809 2000 001C 00F0          LIT = MAR2                  * LOAD ADDR OF COL 1-4                     00136000 D
0040  07A0 0000 0000 00EC          CARD1X4 = LIT                                                          00137000 D
0041  00F0 0000 0000 C060          INPUT - 1 = CPCR            * READ COLS 1-4                            00138000 D
0042  0100 0000 0000 C060          GETADDR - 1 = CPCR          * GET OCTAL VALUE OF PAGE NO. IN COL.6-8 00139000 D
0043  4809 0041 0090 00F0          B L = MIR                   * MULT PAGE NO. BY 256 TO GET BASE ADDR    00140000 D
0044  0230 0000 0000 0060          NXTINSTR = LIT; COMP 8 = SAR  * INTO NXTINSTR REG WHICH WILL           00141000 D
0045  4809 2000 001C 00F0          LIT = MAR2                  * WRITE THE BASE ADDRESS OF SELECTED PAGE00142000 D
0046  0110 0000 0000 004C          OUT - 1 = MPCR              * TO BE USED AS THE BASE ADDRESS TO LOAD 00143000 D
                                                               * THE PROGRAM.                             00144000 D
                                                               *                                          00145000 D
                                                               *                                          00146000 D
                              INPUT:                           * THIS ROUTINE WILL READ THE CONTENT OF    00147000 D
                                                               * THE MEMORY ADDRESS IN MAR2.              00148000 D
0047  A809 0000 0000 0CF0          MR2; IF RDC                 * PERFORM READ                             00149000 D
0048  AC28 0000 0000 00F0          WHEN RDC THEN BEX; JUMP   * READ CONTENTS OF MAR2 INTO B.          00150000 D
                                                               *                                          00151000 D
                                                               *                                          00152000 D
                              GO:                              * THIS ROUTINE RETRIEVES THE PAR CONTENTS00153000 D
                                                               * AND STATUS REG 1 CONTENTS AND PACKS      00154000 D
                                                               * THEM INTO A1 AND THEN JUMPS TO THE       00155000 D
                                                               * EMULATOR                                 00156000 D
0049  0120 0000 0000 0060          GETADDR - 1 = CPCR          * GET ADDRESS IN COL. 5-8 OF "GO" CARD     00157000 D
004A  4809 00C1 4000 00F0          1 L = A1                                                               00158000 D
004B  A200 C0C0 0000 C0A0          COMP 10 = SAR; PSW = LIT                                               00159000 D
004C  4809 AC40 4090 00F0          A1 + B = A1                 * OFFSET ADDRESS BY 1024                   00160000 D
004D  4809 2000 001C C0F0          LIT = MAR2                  * LOAD ADDRESS OF PSW                      00161000 D
004E  0460 C000 0000 C060          INPUT - 1 = CPCR            * RETRIEVE CONTENTS OF PSW                 00162000 D
004F  4809 AC5C 4090 00F0          A1 OR B = MIR, A1           * STORE COMPLETE PSW INTO MIR AND A1       00163000 D
0050  0130 0000 0000 0060          OUTPUT1 - 1 = CPCR          * LOAD PAR REG WITH START ADDRESS OF PROG00164000 D
0051  0140 0000 0000 004C          STARTIME - 1 = MPCR         * START EMULATION OF UYK20                 00165000 D
                                                               * START CLOCK AND FETCH FIRST INST.        00166000 D
                                                               *                                          00167000 D
                                                               *                                          00168000 D
                                                               *                                          00169000 D
                              GETADDR:                         *GET ADDRESS FIELD FROM COLUMNS N-M        00170000 D
                                                               *OF INPUT CARD. ADDRESS WILL BE IN         00171000 D
                                                               *DECIMAL. (N & M STAND FOR CARD COLS)      00172000 D
                                                               *                                          00173000 D
0052  4809 0003 0C30 C0F0          BEX                         * GET PRECEDING MEMORY WORD FROM SWI       00174000 D
0053  4809 0640 2000 C0F0          AMPCR = A2                  *SAVE RETURN                               00175000 D
0054  4809 0041 0B90 40FC          B L = B, CSAR                                                          00176000 D
0055  0300 0000 0000 0090          COMP 24 = SAR;48=LIT        *ISOLATE LSB OF CARD(N-3)XN                00177000 D
```

```
0056  4809 0C40 C000 00F0                O R = A1
0057  4809 A152 C000 00FC                A1 EQL LIT              % TEST FOR BLANK ADDR FIELD
0058  5C0B 0000 0B00 00F0                IF TRUE THEN 0 = B; STEP ELSE SKIP  % IF BLANK ADDR TREAT AS 0
0059  0150 0000 0000 0040                ALLBLANKS - 1 = MPCR   %OUTPUT EQUAL C IN B REG
005A  0160 0000 0000 006C                PACKED-1 = CPCR        %PACK DECIMAL NUMBERS INTO SINGLE WORD
005B  0170 0000 0000 0060                DECOCT-1 = CPCR        %DECODE  THE DECIMAL NUMBERS INTO OCTAL
                                  ALLBLANKS:
005C  4809 C000 0090 00FC                A2 = AMPCR
005D  4809 0000 0000 00FC                STEP                    % NEEDED FOR AMPCR ASSIGN PRIOR TO JUMP
005E  4820 0000 0000 00F0                JUMP
                                                                 %
                                  OUT:                           % THIS ROUTINE PERFORMS A MEMORY WRITE
005F  9809 0000 0000 1CF0                MW2; IF SAI
0060  9C08 C000 0000 00F0                WHEN SAI THEN 0; STEP
                                                                 %
                                                                 %
                                  NEWCARD:                       %CALL IOP TO READ NEXT CARD THEN
                                                                 %JUMP TO CONTROL SPACE CARD ROUTINE.
                                                                 %THIS ROUTINE INSERTS SPACES INTO
                                                                 %HEXADDR AND CARDBUFFER
                                                                 %REMAINING 11 WORDS ARE FILLED WITH
                                                                 %SPACES FOR ECHO PRINT ROUTINE.
0061  4809 0000 0931 00F0                0 = BC8,LCTR
0062  01F0 0000 0000 00E0                31 = LIT                %33 WORDS WILL HAVE SPACES
0063  4809 2000 001C 00F0                LIT = MAR2
0064  0780 0000 0000 C0A0                HEXADDR = LIT; COMP 16 =SAR
0065  4809 0C40 0030 C0F0                B = MIR                 %PUT SPACES INTO MIR
                                                                 %
                                                                 %
0066  0180 0000 0000 0060         SPACES: OUTPUT1 - 1 = CPCR     %WRITE SPACES INTO MEMORY
0067  840B CF45 001E C0F0                IF NOT COV THEN BMAR + 1 = MAR2,INC; STEP ELSE SKIP
0068  065C 0000 0000 0040                SPACES-1 = MPCR
                                                                 %
                                                                 %
                                  CARDFETCH:                     % RETRIEVE CARD
0069  9809 2000 0B00 00F0                LIT = B; IF SAI
006A  07AC 0000 0000 00E0                CARDBUF = LIT           % CARDBUFF ADDRESS INTO B
006B  B80E 0000 0000 00FC                IF IRQ THEN STEP ELSE SKIP  % IRQ INDICATES CRT INPUT
006C  319C 0000 0000 0060                CRTIN - 1 = CPCR
006D  4809 0C40 0C90 C0FC                B = MIR                 % CONTENTS FOR MAILBOX
006E  01AC C0C0 0C0C 0060         BCRD:  EXTOP - 1 = CPCR
006F  06D0 0000 C000 0040                BCRD - 1 = MPCR
0070  980B C0C0 0000 00F0                IF IRQ THEN STEP ELSE SKIP  % IRQ -> FALSE THEN ECHO PRT (PTR)
0071  007C 0000 0000 C040                CONTROLCD - 1 = MPCR   % JUMP TO CONTROL CARD ROUTINE
0072  4809 2000 0090 00F0                LIT = MIR
0073  078C C0C0 0000 00EC                HEXADDR = LIT
0074  4809 0001 0F00 00F0                1 L = BBI
0075  0000 0000 0000 0020                COMP 16 = SAR
0076  4809 0C40 C09C C0F0                B = MIR                 %MIR CONTAINS 1/HEXADDR
                                                                 %
                                                                 %
                                  ECHOPRINTCD:                   % ECHO CARD READ
0077  0180 0000 0000 0060                EXTOP - 1 = CPCR       % JUMP TO EXTOP ROUTINE
0078  0760 C000 0C00 0C40                ECHOPRINTCD - 1 = MPCR % UNSUCCESSFUL IO OPERATION
0079  007C 0000 0000 C040 .              CONTROLCD - 1 = MPCR   % JUMP TO CONTROL CARD ROUTINE
                                                                 %
                                                                 %
                                  EXTOP:                         %THIS ROUTINE PERFORMS THE IOP INTERFACE
                                                                 %BY PASSING TO THE IOP THE FUNCTION
                                                                 %AND THE ADDRESS IN THE MAILBOX. THE IOP
```

```
                                                         *RETURNS THE STATUS OF THE
                                                         *IN THE B REGISTER.
0C7A  1C88 C002 001C 00F0              SET GC2 WHEN GC2 THEN NOT 0 = MAR2
0C7B  9809 00C0 0000 1CF0              MW2; IF SAI
0C7C  9F08 0000 0000 C0F0              WHEN SAI THEN 0; SET INT
0C7D  D809 0000 0C0C C0FC              IF INT
0C7E  D808 00C0 0000 00FC              WHEN INT THEN STEP
0C7F  A809 00C0 0C0C 0CF0              BEX; MR2; IF RDC
0C80  AEC8 0C42 000C C0FC              WHEN RDC THEN NOT 0; RESET GC2
0C81  682F 0000 000C 00F0              IF ABT THEN JUMP ELSE RETN
                                                         *
                                                         *
                            OUTPUT1:
0C82  9809 0000 0C00 1CF0              MW2; IF SAI
0C83  9C28 0000 0000 00F0              WHEN SAI THEN 0; JUMP
                                                         *
                                                         *
                                                         *
0C84  4809 2001 200C 00F0   CRTIN:     LIT L = A2        * CRT READ CODE FOR CARDFETCH ROUTINE
0C85  0060 0000 0C0C C0AC              COMP 16 = SAR; 6 = LIT
0C86  4809 CC53 0B00 C0F0              A2 OR B = B
0C87  482D 0000 0C00 00FC              JUMP
                                                         *
                                                         *
                            PACKED:                      * THIS ROUTINE MUST BE PASSED A 32 BIT
                                                         * WORD IN UNPACKED DECIMAL FORM(4 DIGIT
                                                         * DECIMAL NUMBER). THE NUMBER IS PASSED
                                                         * IN A1.  THE PACKED DECIMAL EQUIVALENT
                                                         * OF THE NUMBER IS RETURNED IN B REGISTER
                                                         * WHICH CONSISTS OF AN 8 DIGIT DECIMAL NO
0C88  49C9 0000 0C00 00F0              SET LC1           * THIS STEP IS OMITTED FOR A 4 DIGIT NO.
0C89  4809 0000 0C30 00F0              0 = MIR           * ZERO MIR
0C8A  4809 00C0 0001 C0F0   NEXT4:     LCTR              * SET COUNTER TO PERFORM LOOP 4 TIMES
0C8B  3030 0000 0C00 C0B0              3 = LIT; COMP 4 = SAR
                            PACKTOP:
0C8C  4809 A001 4C00 00F0              A1 L = A1         * ELIMINATE HIGH ORDER 4 BITS OF MSB CHAR
0C8D  4809 A0C0 8F0C 00F0              A1 R = BBI        * SHIFT A1 RIGHT 28 BITS AND "OR" WITH
                                                         * MIR AND PLACE IN B REGISTER
0C8E  4809 0C41 0082 00F0              B L = MIR,INC     * LEFTMOST DIGIT NOW IN HIGH ORDER
                                                         * POSITION OF MIR.
0C8F  840E A0C1 4C00 00F0              IF NOT COV THEN A1 L = A1; STEP ELSE SKIP   * SHIFT NEXT DIGIT
                                                         * INTO POS. FOR NEXT PASS THROUGH LOOP
0C90  D8BC 0000 0030 C040              PACKTOP - 1 = MPCR  *BRANCH TO TOP OF LOOP
0C91  2819 0000 0000 00FC              IF LC1 THEN SKIP  * CHECK TO SEE IF AN 8 DIGIT NUMBER
0C92  01C0 0000 0C00 004C              PACKEND - 1 = MPCR  * JUMP TO THE END OF THE ROUTINE
                                                         * IF ONLY A 4 DIGIT NUMBER WAS INPUT.
0C93  4809 0F45 001C 00F0              BMAR + 1 = MAR2   *PREPARE MAR TO READ NEXT 4 DIGITS
0C94  A809 00C0 0C0C 0CFC              BEX; MR2; IF RDC  * B NOW CONTAINS LOW ORDER 4 DIGITS
                                                         * OF AN 8 DIGIT NUMBER.
0C95  AC08 0C40 4000 00F0              WHEN RDC THEN B = A1  * WHEN READ COMPLETE, SET A1 EQUAL TO B
0C96  0890 00C0 0C00 0040              NEXT4 - 1 = MPCR  * BRANCH TO THE TOP OF THE LOOP
                            PACKEND:
0C97  482D 0000 0C00 C0F0              JUMP              *RETURN TO CALLING ROUTINE WITH PACKED
                                                         *NUMBER IN B REGISTER
                                                         *
                                                         *
                            DECOCT:                      * THIS ROUTINE WILL CONVERT DECIMAL
                                                         * NUMBERS INTO THEIR OCTAL EQUIVALENTS.
                                                         * THIS ROUTINE REQUIRES A PACKED DECIMAL
                                                         * NUMBER PASSED VIA THE D REGISTER.  THE
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                                                      * OCTAL EQUIVALENT WILL BE RETURNED IN B.00298000 D
0C98  4809 0C40 4C00 00F0           B = A1            * PACKED RESULTS ARRIVE IN B REG          00299000 D
0C99  4809 0000 0B00 00F0           0 = B             * CLEAR B REGISTER                        00300000 D
0C9A  4809 0000 0031 00F0           C = MIR, LCTR     * SET COUNTER FOR 7 ITERATIONS.           00301000 D
0C9B  0060 0000 0000 C0E0           6 = LIT                                                     00302000 D
                                                      * PLACE DECIMAL NUMBER IN A1 AND CLEAR B.00303000 D
0C9C  4809 A000 9C00 C0F0  TOPDEC:  A1 R = A3         * PUT HIGH ORDER 4 BITS OF A1 INTO        00304000 D
0C9D  800C 0000 0000 C030           COMP 4 = SAR      * LOW ORDER 4 BITS OF A3.                 00305000 D
0C9E  4809 A0C1 4C00 00F0           A1 L = A1         * PREPOSITION NEXT DECIMAL DIGIT IN A1.   00306000 D
0C9F  4809 EC41 1800 00F0           A3 + B L = A3, BAD  * MULT DECIMAL DIGIT BY 8               00307000 D
0CA0  700C 0000 0000 C030           COMP 3 = SAR                                                00308000 D
0CA1  4809 CC41 0B02 C0F0           B L = B,INC       * MULT DECIMAL DIGIT BY 2, INCREMENT CTR  00309000 D
0CA2  3000 0000 0000 C030           COMP 1 = SAR      *EFFECTIVELY MULT BY A FACTOR OF 10.      00310000 D
0CA3  4809 EC40 0B00 00F0           A3 + B = B        * PARTIAL SUM OF CONVERSION               00311000 D
0CA4  8C19 A000 9000 00F0           IF COV THEN A1 R = A3; SKIP  * GET LS DIGIT FROM A1 IF DONE 00312000 D
0CA5  09B0 0000 0000 0040           TOPDEC - 1 = MPCR * GO TO TOP OF LOOP                       00313000 D
0CA6  900C 0000 0000 0030           29 = SAR                                                    00314000 D
0CA7  4809 EC40 0B00 00F0           A3 + B = B        * ADD LS DIGIT TO B AND RETURN OCTAL      00315000 D
                                                      * VALUE IN B REGISTER.                    00316000 D
0CA8  482D 0000 0000 00F0           JUMP                                                        00317000 D
                                                      *                                         00318000 D
                                                      *                                         00319000 D
                           DATA:                      * CONVERT DECIMAL DATA IN COL 13-20 INTO  00320000 D
                                                      * OCTAL AND STORE AT THE ADDRESS IN       00321000 D
                                                      * COL 4-8                                 00322000 D
0CA9  051C 0000 0000 006C           GETADDR - 1 = CPCR  * RETRIEVE ADDR IN COL 4-8 IN OCTAL     00323000 D
0CAA  4809 0C40 1000 00F0           B = A3            * TRANSFER ADDR TO A3 REG                 00324000 D
0CAB  4809 2C00 001C 0DF0           LIT = MAR2        * LOAD ADDRESS OF COL 13-16               00325000 D
0CAC  07D0 0000 0000 C0E0           CARD13X16 = LIT                                             00326000 D
0CAD  046C 0000 0C00 0060           INPUT - 1 = CPCR  * READ IN COL 13-16                       00327000 D
0CAE  4809 0C40 4C00 D0F0           B = A1                                                      00328000 D
0CAF  0870 0000 0000 0060           PACKED - 1 = CPCR * PACK DATA IN COL 13-20                  00329000 D
0CB0  4809 E0C0 2000 D0FC           A3 = A2           * SWITCH TEMP ADDRESS STORAGE             00330000 D
0CB1  097C 0000 0000 0060           DECOCT - 1 = CPCR * CONVERT DECIMAL TO OCTAL                00331000 D
0CB2  4809 0C40 0C00 00F0           B = MIR           * MIR CONTAINS DATA IN OCTAL              00332000 D
0CB3  4809 C012 000C 00F0           A2 EOL 0          * SET UP LOGICAL TEST FOR BLANK ADDR      00333000 D
0CB4  680B 0000 000C 00F0           IF TRUE THEN STEP ELSE SKIP                                 00334000 D
0CB5  01DC 0000 0000 004D           INLINE - 1 = MPCR *IF ADDR = 0 ADD DATA IN NEXT ADDR        00335000 D
0CB6  4809 C0C0 001C 00F0           A2 = MAR2         * PUT MEMORY ADDR IN MAR2 FOR WRITE OP    00336000 D
0CB7  05E0 0000 0000 C040           OUT - 1 = MPCR    * WRITE DATA IN MEMORY AND GET NEXT CARD  00337000 D
                                                      *                                         00338000 D
                                                      *                                         00339000 D
                           INLINE:                    * THIS ROUTINE WILL INSERT DATA INTO THE  00340000 D
                                                      * ADDRESS CONTAINED IN THE NXTINSTR       00341000 D
                                                      * REG.  THE DATA TO BE WRITTEN IS IN MIR.00342000 D
0CB8  4809 2000 201C C0F0           LIT = MAR2,A2     * PUT ADDR OF NEXTINST INTO MAR2, A2      00343000 D
0CB9  0230 0000 0000 C0E0           NXTINSTR = LIT                                              00344000 D
0CBA  0460 0000 C000 0D6D           INPUT - 1 = CPCR  * READ CONTENTS OF NXTINSTR               00345000 D
0CBB  4809 0C40 0C1C C0FD           B = MAR2          * PLACE CONTENTS OF NXTINSTR INTO MAR2    00346000 D
0CBC  0810 0000 DC0C 0060           OUTPUT1 - 1 = CPCR  * PLACE DATA AT THAT ADDRESS(MAR2)      00347000 D
0CBD  4809 0C45 0030 C0F0           B + 1 = MIR       * CREATE NEXT ADDR FOR NXTINSTR           00348000 D
0CBE  4809 C000 0C1C C0F0           A2 = MAR2         * WRITE NEW ADDR IN NXTINSTR              00349000 D
0CBF  05E0 0000 0C00 0040           OUT - 1 = MPCR    * REG. AND GET THE NEXT CARD              00350000 D
                                                      *                                         00351000 D
                                                      *                                         00352000 D
                           SETINDEXREG:               * THIS ROUTINE WILL EXAMINE COL. 2 FOR    00353000 D
                                                      * THE GENERAL REGISTER STACK NO. AND      00354000 D
                                                      * COL. 7-8 FOR THE REGISTER NO.  THE      00355000 D
                                                      * CONTENTS OF COL. 13-20(ONLY 16-20 USED)00356000 D
                                                      * WILL THEN BE CONVERTED TO OCTAL AND     00357000 D
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                                                                  * STORED IN THE DESIRED GENERAL REGISTER.00358000 D
00C0  0460 0000 0000 C060                INPUT - 1 = CPCR         * REREAD COL. 1 - 4                         00359000 D
00C1  4809 0C41 CB00 00F0                B L = B                  * ISOLATE COLUMN 2                          00360000 D
00C2  0000 0000 0000 0030                COMP 8 = SAR                                                         00361000 D
00C3  4809 0C40 CB00 00F0                B R = B,A1                                                           00362000 D
00C4  4809 A00E 0B00 00F0                A1 - 1 = B               * B IS NOW 0(GEN REG. NO. 1) OR 1(NO. 2)    00363000 D
00C5  4809 0C41 CB00 C0F0                B L = B                  * ADDRESS OF GENERAL REGISTER STACK         00364000 D
00C6  8000 0000 0000 0030                COMP 4 = SAR             * MULTIPLY BY 16                            00365000 D
00C7  4809 0C41 0028 00F0                B L = BR1,LMAR           * STORE BASE ADDR OF GEN REG STACK          00366000 D
00C8  0000 0000 0000 0030                COMP 8 = SAR             * SHIFT TO PROPER POS. FOR BR1              00367000 D
00C9  4809 2000 0C1C 00F0                LIT = MAR2               * LOAD ADDR OF CARD COL 5-8                 00368000 D
00CA  07B0 C000 0000 C0EC                CARD5X8 = LIT                                                        00369000 D
00CB  046C 0000 0000 C060                INPUT - 1 = CPCR         * READ CARD COL. 5-8                        00370000 D
00CC  4809 0C41 CB0C 00FC                B L = B                  * ISOLATE CARD COL 7-8                      00371000 D
00CD  000C 0000 0000 0020                COMP 16 = SAR                                                        00372000 D
00CE  4809 0C40 C000 C0F0                B R = A1                 * A1 CONTAINS COL 7-8(GEN REG NO.)          00373000 D
00CF  088C 0000 0000 C060                PACKED = CPCR            * JUMP TO 2ND LINE IN ROUTINE(4 DIGIT NO)00374000 D
00D0  0970 0000 0000 C060                DECOCT - 1 = CPCR        * B HAS OCTAL VALUE OF GEN REG NUMBER       00375000 D
00D1  4809 0000 0000 20F0                ASR                      * SET MAR1 AS MOST RECENTLY REFERENCED      00376000 D
00D2  4809 0F40 C000 00F0                BMAR R = A1              * MOVE BASE ADDR TO A1 FROM BR1             00377000 D
00D3  0000 0000 0000 0010                B = SAR                  * SHIFT OMAR TO ISOLATE BR1                 00378000 D
00D4  4809 AC41 002C 00F0                A1 + B L = BR1           * CREATE GEN REG ADDR(BASE + OFFSET)        00379000 D
00D5  0700 00C0 0000 00B0                COMP 8 = SAR; CARD13X16 = LIT  * SHIFT FOR BR1                       00380000 D
00D6  4809 2000 001C 00F0                LIT = MAR2               * ADDRESS OF DATA                           00381000 D
00D7  0460 0000 C000 0060                INPUT - 1 = CPCR         * READ IN DATA                              00382000 D
00D8  0510 0000 0000 0060                GETADDR - 1 = CPCR                                                   00383000 D
00D9  4809 0000 0000 20F0                ASR                      * SET MAR1 AS MOST RECENTLY REFERENCED      00384000 D
00DA  48C9 0F40 801C C0F0                BMAR R = MAR2            * LOAD GEN REG ADDR INTO MAR2               00385000 D
00DB  0000 0000 0000 C010                B = SAR                  * SHIFT TO ISOLATE BR1                      00386000 D
00DC  4809 0C40 0080 00F0                B = MIR                  * B HAS OCTAL VALUE OF DATA                 00387000 D
00DD  05EC 0000 0000 C040                OUT-1 = MPCR             *WRITE DATA FROM COL. 13-20 INTO            00388000 D
                                                                  *SPECIFIED GENERAL REGISTER                 00389000 D
                                                                  *                                           00390000 D
                                                                  *                                           00391000 D
                            BREAKPOINT:                           *SET UP BREAKPOINT REGISTER AND SET         00392000 D
                                                                  * STATUS BITS                               00393000 D
00DE  4809 0000 0C00 00F0                BEX                      * FILL B WITH CARD COL 1-4   (FROM SWI)     00394000 D
00DF  4809 0C41 4C00 C0F0                B L = A1                 * ISOLATE THE R,W,B CHARACTER               00395000 D
00E0  0000 0000 0000 0030                COMP 8 = SAR                                                         00396000 D
00E1  4809 A000 C000 00F0                A1 R = A1                *ISOLATE COLUMN 2                           00397000 D
00E2  0000 0000 000C 003C                24 = SAR                                                             00398000 D
00E3  4809 2000 001C 00F0                LIT = MAR2               * WRITE PSW INTO B                          00399000 D
00E4  0200 0000 0000 00E0                PSW = LIT                                                            00400000 D
00E5  0460 C000 0000 0060                INPUT - 1 = CPCR         * INPUT FROM MEMORY                         00401000 D
00E6  4809 A152 0C00 00FC                A1 EOL LIT               *CHECK FOR CHARACTER :R:                    00402000 D
00E7  0290 C000 0000 00E0                41 = LIT                                                             00403000 D
00E8  6419 A152 0000 00F0                IF FALSE THEN A1 EOL LIT; SKIP                                       00404000 D
00E9  01E0 00C0 0000 C040                BRKREAD - 1 = MPCR       *JUMP TO  BREAKPOINT READ SUBFUNCTION       00405000 D
00EA  036C 0000 0000 00E0                54 = LIT                 *CHECK FOR :W: CHARACTER                    00406000 D
00EB  6019 C000 0000 00F0                IF FALSE THEN SKIP                                                   00407000 D
00EC  01F0 0000 0000 004C                BRKWRITE - 1 = MPCR      * JUMP TO BREAKPOINT WRITE SUBFUNCTION      00408000 D
00ED  020C 0000 0000 0040                BRKBOTH -1 = MPCR        * DEFAULTS TO BREAKPOINT BOTH (R+W)         00409000 D
                                                                  *                                           00410000 D
                                                                  *                                           00411000 D
                            BRKREAD:                              * THIS ROUTINE SETS UP THE BREAKPOINT       00412000 D
                                                                  * REGISTER AND SETS THE READ STATUS BITS 00413000 D
00EE  4809 00C1 4000 00F0                1 L = A1                                                             00414000 D
00EF  8000 00C0 0C00 C010                COMP 20 = SAR                                                        00415000 D
00F0  4809 AC5C 005C 00F0                A1 OR B = MIR            * SET BIT # 20 OF PSW REG                   00416000 D
00F1  081C 0000 0000 0060                OUTPUT1 - 1 = CPCR       * WRITE PSW INTO MEMORY                     00417000 D
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00F2  0210 0000 0000 0040          WRITEBRKPT - 1 = MPCR % JUMP TO WRITE BREAKPOINT REGISTER       00418000 D
                                                         %                                         00419000 D
                             BRKWRITE:                   % THIS ROUTINE SETS UP THE BREAKPOINT     00420000 D
                                                         % REGISTER AND SETS THE WRITE STATUS BITS00421000 D
00F3  4809 00C1 4000 00F0          1 L = A1                                                        00422000 D
00F4  3000 0000 0000 0010          COMP 21 = SAR                                                   00423000 D
00F5  4809 AC5C 0090 00F0          A1 OR B = MIR         %SET BIT 21 OF PSW REG                    00424000 D
00F6  0810 0000 000C 0060          OUTPUT1 - 1 = CPCR    % WRITE PSW INTO MEMORY                   00425000 D
00F7  022C 0000 0000 0040          WRITEBRKPT - 1 = MPCR % JUMP TO WRITE BREAKPOINT REGISTER       00426000 D
                                                         %                                         00427000 D
                             BRKBOTH:                    % THIS ROUTINE  SETS UP THE BREAKPOINT    00428000 D
                                                         % REGISTER AND SETS THE STATUS BITS FOR   00429000 D
                                                         % BOTH READ AND WRITE                     00430000 D
00F8  4809 2001 9000 00F0          LIT L = A1                                                      00431000 D
00F9  030C 0000 0000 00A0          COMP 16 = SAR; 48 = LIT  % SET UP A1 WITH MASK BIT POS. 21/20   00432000 D
00FA  4809 AC5C 0090 00F0          P OR A1 = MIR         % PUT BREAKPOINT CODE INTO SR1 BIT POS    00433000 D
                                                         % 21 AND 20                               00434000 D
00FB  0810 0000 0000 0060          OUTPUT1 - 1 = CPCR    % WRITE PSW INTO MEMORY                   00435000 D
                                                         %                                         00436000 D
                                                         %                                         00437000 D
                             WRITEBRKPT:                 %THIS ROUTINE WRITES THE DECIMAL ADDR     00438000 D
                                                         % INTO THE BREAKPOINT REGISTER AND        00439000 D
                                                         % AND INTO  REGISTER BRI                  00440000 D
00FC  4809 2000 001C 00F0          LIT = MAR2            % RETRIEVE CARD1X4 CONTENTS               00441000 D
00FD  07A0 0000 0000 00E0          CARD1X4 = LIT                                                   00442000 D
00FE  0460 0000 0000 0060          INPUT - 1 = CPCR      % INPUT INTO B                            00443000 D
00FF  0510 0000 0000 0060          GETADDR - 1 = CPCR    % OBTAIN ADDRESS FROM COL 4-8             00444000 D
0100  4809 2000 001C 00F0          LIT = MAR2                                                      00445000 D
0101  0210 0000 0000 00E0          BKPT = LIT            % GET ADDRESS OF BKPT REG                 00446000 D
0102  4809 0C40 0030 00F0          B = MIR               % B HAS BINARY  ADDRESS VALUE             00447000 D
0103  4809 0C41 0020 00F0          B L = BR1             %INSERT BREAKPOINT ADDR INTO BR1          00448000 D
0104  0000 0000 0000 0030          COMP 8 = SAR                                                    00449000 D
0105  0810 0000 0000 006C          OUTPUT1 - 1 = CPCR    % WRITE OUT ADDR INTO BKPT REG            00450000 D
0106  060C 0000 0000 0040          NEWCARD - 1 = MPCR    % RETURN TO NEW CARD ROUTINE              00451000 D
                                                         %                                         00452000 D
                                                         %                                         00453000 D
                             DOUDLEWORD:                 %HANDLES SECOND WORD OF TWO WORD INSTR    00454000 D
0107  4809 E000 880C 00FC          A3 R = B              % PUT COL 16 IN LSB                       00455000 D
0108  07D0 0000 0000 00A0          16 = SAR; CARD13X16 = LIT                                       00456000 D
0109  4809 2000 001C 00F0          LIT = MAR2            %RELOAD ADDR OF CARD COL 13-16            00457000 D
010A  0520 0000 0000 0060          GETADDR = CPCR        %OMIT HEX STEP IN GETADDR, B CONTAINS     00458000 D
010D  4809 0C40 200C 00F0          B = A2                % COL 16 DIGIT IN LSB OF B                00459000 D
010C  023C 0000 0000 0060          LOADINSTR - 1 = CPCR  %LOAD OCTAL VALUE OF DATA INTO SECOND     00460000 D
010D  060C 0000 0000 0040          NEWCARD - 1 = MPCR    % WORD OF DOUBLEWORD INSTRUCTION AND      00461000 D
                                                         %                                         00462000 D
                                                         %                                         00463000 D
                             INSTRUCTION:                % THIS ROUTINE WILL PACK AN INSTRUCTION   00464000 D
                                                         % INPUT CARD INTO A 16 BIT INSTRUCTION    00465000 D
                                                         % AND PLACE IT IN THE LS 16 BITS OF A     00466000 D
                                                         % 32 BIT WORD.  RITYPE1 INSTRUCTIONS ARE 00467000 D
                                                         % ARE SELECTED  AND HANDLED BY A SEPARATE00468000 D
                                                         % ROUTINE.                                00469000 D
010E  4809 2000 001C 00F0          LIT = MAR2                                                      00470000 D
010F  97B0 0000 0000 00A0          CARD5X8 = LIT; 21 = SAR                                         00471000 D
0110  0460 0000 0000 0060          INPUT - 1 = CPCR      % READ THE CONTENTS OF COL. 5-8 INTO B    00472000 D
0111  4809 0C40 A000 00F0          B R = A2              % ISOLATE 11 BITS (CHARACTER + 3 BITS)    00473000 D
0112  4809 0C41 1000 00F0          B L = A3              % ISOLATE NEXT OCTAL DIGIT                00474000 D
0113  3000 0000 000C 002C          COMP 13 = SAR                                                   00475000 D
0114  4809 E000 9000 00F0          A3 R = A3                                                       00476000 D
0115  9000 0000 0000 0030          29 = SAR                                                        00477000 D
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0116  4809 C000 0090 00F0        A2 = AMPCR              % SET UP A Y-SELECT                          00478000 D
0117  4809 E641 0090 00F0        A3 + AMPCR L = AMPCR    % PACK OPCODE IN SIX BITS                    00479000 D
0118  A000 C000 0030 C030        COMP 2 = SAR            % IN A2 AND SHIFT 2 BITS FOR NEXT FIELD      00480000 D
0119  4809 0C41 1030 40F0        B L = A3, CSAR          % ISOLATE FUNCTION BITS                      00481000 D
011A  27C0 C000 0000 C080        COMP 30 = SAR; CARD9X12 = LIT                                        00482000 C
011B  4809 E000 9030 00F0        A3 R = A3                                                            00483000 D
011C  4809 E640 2030 00F0        A3 + AMPCR = A2         % PACK FUNCTION BITS (0-3) INTO A2           00484000 D
011D  4809 2003 001C C0F0        LIT = MAR2                                                           00485000 D
011E  0460 0C00 0000 0060        INPUT - 1 = CPCR        % READ IN NEXT 4 COL. (9-12)                 00486000 D
011F  4809 2C55 9030 C0F0        B AND LIT = A1                                                       00487000 D
0120  0FF0 0000 0000 00E0        255 = LIT               % ISOLATE COL. 12 TO CHECK FOR COMMA         00488000 D
0121  4809 A152 0030 00F0        A1 EOL LIT                                                           00489000 D
0122  03A0 0000 0030 C0E0        59 = LIT                % CODE FOR COMMA                             00490000 D
0123  5008 0000 0000 C0F0        IF FALSE THEN STEP ELSE SKIP % TREAT COL. 10-12 AS "C" FIELD         00491000 D
                                                         % OF RITYPE 1 INSTRUCTION                    00492000 D
0124  0240 0003 0030 0040        RITYPE1 - 1 = MPCR      % TRANSFER TO RITYPE1 ROUTINE                00493000 D
                                                         % CARD HAS COL. 10-11 AS "A" FIELD           00494000 D
                                                         % COL. 13-14 AS "M" FIELD                    00495000 D
0125  4809 0C41 0830 C0F0        B L = B                 %ISOLATE CC 10,11                            00496000 D
0126  1000 0003 0030 0020        COMP 15 = SAR                                                        00497000 D
0127  4809 0C40 C030 C0F0        B R = A1                % ISOLATE 1 BIT OF CC 10 + 3 BITS            00498000 D
0128  8000 0000 C030 0030        28 = SAR                                                             00499000 D
0129  4809 0C40 8800 C0F0        B R = B                                                              00500000 D
012A  B070 0003 0000 00A0        23 = SAR; 7 = LIT       % ISOLATE CC 11 (3BITS) INTO B               00501000 D
012B  4809 2C56 0830 00F0        B AND LIT = B                                                        00502000 D
012C  4809 AC40 0C40 C0F0        A1 + B = AMPCR          % INSERT "A" FIELD INTO AMPCR                00503000 D
012D  4809 C0C1 2000 00F0        A2 L = A2                                                            00504000 D
012E  9700 0C03 0000 0080        COMP 4 = SAR; CARD13X16 = LIT                                        00505000 D
012F  4809 C641 2030 00F0        A2 + AMPCR L = A2       % 4 BITS FOR :M: FIELD                       00506000 D
0130  4809 2003 001C C0F0        LIT = MAR2                                                           00507000 D
0131  0460 0000 0030 006C        INPUT - 1 = CPCR                                                     00508000 D
0132  4809 CC41 4830 C0F0        B L = A1, B             %ISOLATE BIT WHICH IS COL 13 DIGIT(1,0)      00509000 D
0133  100C 0C00 003C C030        COMP 7 = SAR                                                         00510000 D
0134  4809 A000 C03C 00F0        A1 R = A1               %FILL A1 WITH BIT-0-0-0 (LSB)                00511000 D
0135  9C00 0003 0030 0030        28 = SAR                                                             00512000 D
0136  4809 0C41 1830 C0F0        B L = A3,B              %PUT COL14 IN MSB OF A3,B                    00513000 C
0137  2000 C0C0 003C 0030        COMP 6 = SAR                                                         00514000 D
0138  4809 0C40 8830 00F0        B R = B                 %PUT COL14 IN LSB OF B                       00515000 D
0139  9000 C0C0 0C30 0030        29 = SAR                                                             00516000 D
013A  4809 AC40 0E3C C0F0        A1 + B = B              % COMBINE COL. 13 AND 14                     00517000 D
013B  4809 CC40 2000 C0F0        A2 + B = A2             % FINISH BUILDING 16 BIT INSTR               00518000 D
013C  0250 0003 0000 006C        LOADINSTR - 1 = CPCR    % LOAD INSTRUCTION(A3 UNCHANGED)             00519000 D
013D  4809 E001 1000 C0F0        A3 L = A3               % A3 CONTAINS COLS. 15-16 IN UPPER HALF      00520000 D
013E  9000 00C0 C03C C030        COMP 3 = SAR                                                         00521000 C
013F  4809 E000 C030 C0F0        A3 R = A1               % SET UP COL. 15 IN LSB OF A1                00522000 D
0140  03A0 0003 0C30 0080        24 = SAR; 58 = LIT                                                   00523000 D
0141  4809 A152 0C3C 00FC        A1 EOL LIT              %CHECK FOR COMMA(,)                          00524000 D
0142  68C0 0000 C000 00F0        IF TRUE THEN STEP ELSE SKIP                                          00525000 D
0143  1060 C0C3 C03C 0040        DOUBLEWORD - 1 = MPCR    %COLS. 16-?- OF CARD CONTAIN DECIMAL        00526000 D
                                                         % :Y: FIELD                                  00527000 D
0144  0600 00C0 C0DC CC4C        NEWCARD - 1 = MPCR      % GET NEW CARD                               00528000 D
                                                         %                                            00529000 D
                                                         %                                            00530000 D
                       LOADINSTR:                        % THIS ROUTINE WILL LOAD AN INSTRUCTION      00531000 D
                                                         % WHICH IS CONTAINED IN A2                   00532000 D
                                                         % INTO THE NEXT APPROPRIATE S-MEMORY WORD00533000 D
0145  4809 0640 403C C0F0        AMPCR = A1              % A1 IS A TEMP RETURN ADDRESS REG            00534000 D
0146  4809 20C3 0C1C 00F0        LIT = MAR2                                                           00535000 D
0147  0230 0000 C03C 00E0        NXTINSTR = LIT          % READ NEXT LOAD ADDRESS FROM NXTINSTR       00536000 D
0148  4809 00C0 0C71 00F0        LCTR                    % SAVE NXTINSTR IN CTR (COMPLEMENTED)        00537000 D
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0149  0460 0000 0000 0060           INPUT - 1 = CPCR                                              00538000 D
014A  4809 0C43 001C 00F0           B = MAR2                % PLACE LOAD ADDRESS INTO MAR2        C0539000 0
014B  4809 0C46 0B0C 00F0           B + 1 = B               % INCREMENT LOAD ADDRESS              00540000 D
014C  4809 C000 C030 00F0           A2 = MIR                % TRANSFER INSTRUCTION WORD IN A2 TO MIR 00541000 0
014D  0810 0003 0000 0060           OUTPUT1 - 1 = CPCR      % AND WRITE INTO S-MEMORY             00542000 0
014E  4809 CB02 801C 00F0           NOT CTR R = MAR2        % WRITE LOAD ADDRESS                  00543000 D
014F  3000 0000 0030 0030           29 = SAR                % INTO NXTINSTR                       00544000 D
0150  4809 0C40 0030 00F0           B = MIR                                                       00545000 D
0151  0810 0000 0000 0060           OUTPUT1 - 1 = CPCR      % MEMORY WRITE                        00546000 D
0152  4809 A000 0030 00F0           A1 = AMPCR              % REINSTALL RETURN ADDRESS            00547000 D
0153  4809 0000 0030 00F0           STEP                    % REQUIRED BEFORE JUMP                00548000 0
0154  4820 0003 0030 00F0           JUMP                                                          CC549C0C 0
                                                            %                                     00550000 D
                                                            %                                     00551000 D
                       MACHSTAT:                            % THIS ROUTINE WILL DISPLAY           0C552000 D
                                                            % THE AN/UYK-20 REG CONTENTS.         0C553000 D
                                                            % IF M1  CONTROL CARD IS USED, THE    CC554000 0
                                                            % OUTPUT WILL BE DISPLAYED ON THE CRT.  00555000 0
                                                            % THE SWI CONTAINS CC COL. 1-4.       C0556000 0
0155  4809 2003 0C1C 00F0           LIT = MAR2, BEX         % LOAD ADDR OF SR#2 INTO MAR2         00557000 D
C156  0220 0000 0000 00E0           STATUS2 = LIT                                                 00558000 0
C157  4809 0C40 8030 00F0           B R = B                 % CC COL. 2 INTO LS BYTE OF B         00559000 D
C158  03FC 0003 0000 00A0           16 = SAR; 63 = LIT                                            00560000 0
C159  4809 2C55 2000 C0F0           LIT AND B = A2          % MASK OFF COL. 2                     00561000 0
C15A  1000 0003 0030 0000           1 = SAR                                                       00562000 D
015B  4809 C002 0030 00FC           A2 EOL 1                % CHECK FOR M1                        00563000 0
015C  5C19 18C1 C03C 00F0           IF TRUE THEN B10C C = A1; SKIP  % SET BIT 30 OF SR#2 FOR CRT  00564000 0
015D  4809 0000 4030 00F0           0 = A1                                                        0C565000 D
015E  0460 0003 0000 0060           INPUT - 1 = CPCR        % READ IN CONTENTS OF SR#2 INTO B     00566000 D
015F  4809 AC5C C030 00F0           A1 OR B = MIR           % SET APPROPRIATE SR#2 BITS           00567000 0
0160  0810 0003 0030 0060           OUTPUT1 - 1 = CPCR      % WRITE NEW SR#2                      CC568000 D
0161  0260 0003 0030 0060           DUMPREG - 1 = CPCR      % DISPLAY REG CONTENTS                00569000 D
0162  0600 0000 0030 0040           NEWCARD - 1 = MPCR      % FETCH NEXT CARD                     00570000 D
                                                            %                                     0C571000 0
                                                            %                                     0C572000 D
                       RESERVESPACE:                        % THIS ROUTINE WILL RESERVE A DECIMAL  00573000 D
                                                            % NUMBER OF MEMORY CELLS AS INDICATED BY C057400C D
                                                            % COL. 4-8.                           00575000 0
0163  0510 0003 0030 0060           GETADDR - 1 = CPCR      % GET NUMBER OF CELLS AND CONVERT TO OCT.00576000 0
C164  4809 0C40 4000 00F0           B = A1                  % A1 CONTAINS NUMBER OF CELLS BEING SAVE00577C0C 0
0165  4809 2003 001C 00F0           LIT = MAR2                                                    00578000 0
0166  0230 0000 000C C0E0           NXTINSTR = LIT                                                00579000 D
0167  0460 0003 0030 0060           INPUT - 1 = CPCR        % READ PRESENT NXTINSTR REG CONTENTS  00580000 D
C168  4809 AC40 0030 00F0           A1 + B = MIR            % NEXT INSTRUCTION ADDR TO MIR        0C581000 D
0169  05E0 0003 0000 0040           OUT - 1 = MPCR          % WRITE OUT A NEW NEXT INST LOCATION  00582000 D
                                                            % INTO THE NXINSTR REG                00583000 D
                                                            %                                     0C584000 0
                                                            %                                     CC585000 D
                       RITYPE1:                             % THIS ROUTINE PACKS THE "C" FIELD INTO 00586000 C
                                                            % A2 (0 FIELD IN CARD COL. 10-12)     C0587000 D
C16A  4809 0C40 9000 00F0           B R = A3                % COL 10 TO LS 3 BITS OF A3           00588000 D
016B  0070 0000 0030 00A0           16 = SAR; 7 = LIT                                             00589000 0
016C  4809 E157 100C C0FC           A3 AND LIT L = A3       % ISOLATE COL 10 + 3 BITS INTO LSB OF A3 00590000 D
016D  3000 0003 0030 0030           COMP 3 = SAR                                                  0C591000 D
016E  4809 0C40 C000 C0F0           B R = A1                % COL 11 TO LSB OF A1                 00592000 D
016F  0000 00C0 C000 C010           8 = SAR                                                       C0593000 D
0170  4809 A155 0040 00FC           A1 AND LIT = AMPCR      % ISOLATE COL 11 INTO AMPCR           00594000 D
0171  4809 E653 1030 00F0           A3 OR AMPCR L = A3      % A3 = COLS. 10,11, + 3 BLANKS        00595000 D
0172  3000 0000 0030 003C           COMP 3 = SAR                                                  00596000 D
0173  4809 2C56 0030 G0F0           LIT AND B = B           % ISOLATE COL. 12                     C0597000 D
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0174  4809 EC5C 0B0C 00FC          A3 OR B = B              % B= C000/C0+COL. 10,11,12              00598000 D
0175  4809 C001 2C00 00F0          A2 L = A2                % PREPARE A2 FOR ADDITION OF B          00599000 D
0176  0000 00C0 0030 0030          COMP 8 = SAR                                                     00600000 D
0177  4809 CC40 2000 00F0          A2 + B = A2              % PACK REMAINING BITS INTO A2           00601000 D
0178  1440 0C0D 0000 CC60          LOADINSTR - 1 = CPCR     % INSTRUCTION WORD RITYPE 1 COMPLETED   00602000 D
0179  05EC 0000 0C00 C040          OUT - 1 = MPCR                                                   00603000 D
                                                            %                                       00604000 D
                                                            %                                       00605000 D
                          SETPAGING:                        % THIS ROUTINE WILL SET THE PAGING BIT  00606000 D
                                                            % (BIT POS. 22) OF THE PSW              00607000 D
017A  4809 2003 001C C0F0          LIT = MAR2                                                       00608000 D
017B  A20C 0000 0000 00A0          PSW = LIT; 22 = SAR                                              00609000 D
017C  046C C003 0000 0060          INPUT - 1 = CPCR         % READ IN CONTENTS OF PSW               00610000 D
017D  4809 0C41 8B30 40F0          B C = B, CSAR            % MOVE PAGING BIT TO LS BIT             00611000 D
C17E  4809 2C53 8B00 00FC          LIT OR B C = B           % PAGING BIT SET(PAGING SELECTED)       00612000 D
017F  0010 0000 000C C0E0          1 = LIT                                                          00613000 D
0180  4809 0C40 0030 C0F0          B = MIR                  % CONTENTS OF PSW INTO MIR              00614000 D
0181  05E0 C000 0C30 0040          OUT - 1 = MPCR                                                   00615000 D
                                                            %                                       00616000 D
                                                            %                                       00617000 D
                          CHARSTRING:                       % THIS ROUTINE WILL READ THE CHARACTER  00618000 D
                                                            % STRING STARTING IN COL. 9 UNTIL FINDING00619000 D
                                                            % A QUOTE ("). THE STRING WILL THEN BE  00620000 D
                                                            % STORED AT THE ADDRESS IN COL. 4-8. IF 00621000 D
                                                            % COL. 4-8 IS BLANK, THE STORAGE ADDRESS 00622000 D
                                                            % WILL DEFAULT TO THE ADDRESS IN NXTINSTR00623000 D
0182  2809 0000 0000 00F0          IF LC1                   % CLEAR CONDITION BITS                  00624000 D
C183  3809 00C0 0C0C 00F0          IF LC2                                                           00625000 D
0184  0510 0CC0 0030 0060          GETADDR - 1 = CPCR       % GET ADDRESS IN COL. 4-8               00626000 D
0185  4809 20C3 001C C0F0          LIT = MAR2               % MAR2 CONTAINS ADDR OF NEXT INSTRUCTION 00627000 D
0186  0230 0000 0C30 00E0          NXTINSTR = LIT                                                   00628000 D
0187  4809 0C52 0C30 00F0          B EOL 0                  % CHECK FOR BLANK ADDRESS FIELD         00629000 D
0188  6A46 0000 00C0 C0F0          IF TRUE THEN SET LC2; STEP ELSE SKIP                             00630000 D
C189  0460 0000 000C 0060          INPUT - 1 = CPCR         % READ CONTENTS OF NXTINSTR             00631000 D
018A  4809 0C43 4C30 C0F0          B = A1                   % A1 CONTAINS ADDR TO BE WRITTEN INTO   00632000 D
018B  4809 20C3 001C CCF0          LIT = MAR2               % SET UP READ ADDR OF COL. 9-12 IN MAR2 00633000 D
C18C  07C0 C000 0030 00EC          CARD9X12 = LIT                                                   00634000 D
C18D  046C 0000 0C30 0060 MORECHAR: INPUT - 1 = CPCR         % READ A 4 CHARACTER BLOCK              00635000 D
018E  0030 0003 0030 00EC          3 = LIT                                                          00636000 D
018F  4812 G0C3 0031 00F0          LCTR; SAVE               % SET UP COUNTER FOR 4 ITERATIONS       00637000 D
0190  4809 0C41 8D32 00F0          B C = B, MIR, INC        % SHIFT 1 CHARACTER INTO B TO BE ANALYZED00638000 D
0191  0000 0000 0000 0010          8 = SAR                                                          00639000 D
0192  4809 2C56 2C0C 00F0          LIT AND B = A2           % EXTRACT RIGHTMOST CHARACTER           00640000 D
C193  03F0 0003 000C 00E0          63 = LIT                 % SET UP 6 BIT MASK                     00641000 D
0194  4809 C152 0C30 00F0          A2 EOL LIT                                                       00642000 D
C195  00F0 C000 CC30 00E0          15=  LIT                 % TEST FOR " (0F)                       00643000 C
0196  6BC9 GCC3 0C30 00F0          IF TRUE THEN SET LC1     % IF A (") IS IN THE STRING SET LC1     00644000 D
0197  0210 03C0 0030 00EC          33 = LIT                 % ADD VALUE TO (") SO THAT SPACE APPEARS 00645000 D
0198  2FC9 2C40 0B3C C0F0          IF LC1 THEN LIT + B = B,MIR; SET LC1                             00646000 D
C199  8029 00C3 0C3C C0F0          IF NOT COV THEN JUMP     % CHECK IF LOOP DONE 4 TIMES            00647000 D
019A  4809 0F46 100C C0F0          BMAR + 1 = A3            % SET UP NEXT READ ADDRESS              00648000 D
019B  4809 AC03 C01C 00F0          A1 = MAR2                % MAR2 NOW HAS WRITE ADDRESS            00649000 D
019C  081C 00C0 CC30 0060          OUTPUT1 - 1 = CPCR       % WRITE 4 CHAR BLOCK TO MEMORY          00650000 D
019D  4809 ACC0 4C30 C0FC          A1 + 1 = A1              % INCREMENT WRITE ADDRESS               00651000 D
019E  280B 00C0 0C00 00F0          IF LC1 THEN STEP ELSE SKIP  % CHECK IF (") WAS FOUND              00652000 D
019F  027C 00C0 0C00 004C          ENDCHARSTRING - 1 = MPCR                                         00653000 D
C1A0  4809 EC03 001C 00F0          A3 = MAR2                % A3 AND MAR2 HAVE READ ADDRESS         00654000 D
01A1  4809 E159 0C30 00F0          A3 LEO LIT               % CHECK IF YOU ARE AT THE END OF THE CARD00655000 D
01A2  0800 00C3 003C 00E0          CARD77X8C = LIT                                                  00656000 D
01A3  700B 0C00 000C 00FC          IF TRUE THEN STEP ELSE SKIP                                      00657000 D
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01A4  18C0 0000 0030 C040            MORECHAR - 1 = MPCR    % READ IN MORE CHARACTERS                 00658000 D
01A5  3008 0000 0030 00F0  ENDCHARSTRING:  IF NOT LC2 THEN STEP ELSE SKIP                             00659000 D
01A6  0600 0000 0030 0040            NEWCARD - 1 = MPCR     % GET NEXT CARD                           00660000 D
01A7  4809 A000 0030 00F0            A1 = MIR               % STORE A1 CONTENTS INTO MIR              00661000 D
01A8  4809 2003 001C 00F0            LIT = MAR2             % LOAD MAR2 WITH ADDR OF NXTINSTR         00662000 D
01A9  0230 0000 0030 00E0            NXTINSTR = LIT                                                   00663000 D
01AA  05EC 0000 0000 0040            OUT - 1 = MPCR         % UPDATE CONTENTS OF NXTINSTR             00664000 D
                                                            %                                         00665000 D
                                                            %                                         00666000 D
                           SWITCHES:                        % THIS ROUTINE WILL EMULATE THE PHYSICAL  00667000 D
                                                            % SETTING OF THE UYK-20 PROGRAM STOP      00668000 D
                                                            % SWITCHES 1 AND 2.  MAR2 CONTAINS ADDR   00669000 D
                                                            % ADDRESS OF COL 1-4.  COL 2 WILL CONTAIN00670000 D
                                                            % A 1(INDICATES SW#1 ON) OR A 2(INDICATES00671000 D
                                                            % SW#2 IS ON).  BITS 30 AND 29 OF THE     00672000 D
                                                            % PSW WILL BE SET TO A "1" TO INDICATE    00673000 D
                                                            % SWITCH 1 AND SWITCH 2 RESPECTIVELY.     00674000 D
01AB  0460 0000 0030 C060            INPUT - 1 = CPCR       % REREAD COL. 1-4 INTO B                  00675000 D
01AC  4809 0C40 C030 C0FC            B R = A1               % COL. 2 INTO LS BYTE  OF A1              00676000 D
01AD  03F0 0003 0000 00A0            16 = SAR; 63 = LIT                                               00677000 D
01AE  4809 A156 4030 00F0            A1 AND LIT = A1        % MASK OUT LS BYTE OF A1                  00678000 D
01AF  4809 20C3 001C 00F0            LIT = MAR2             % MAR2 CONTAINS ADDR OF PSW               00679000 D
01B0  0200 C0C0 0030 C0E0            PSW = LIT                                                        00680000 D
01B1  046C 00C0 0030 C060            INPUT - 1 = CPCR       % READ INTO B THE CONTENTS OF THE PSW     00681000 D
01B2  4809 A152 0030 00F0            A1 EOL LIT             % CHECK IF SW#1 SET                       00682000 D
01B3  0010 0000 0030 00EC            1 = LIT                                                          00683000 D
01B4  680B 0000 0030 00F0            IF TRUE THEN STEP ELSE SKIP                                      00684000 D
01B5  0280 0003 000C 0040            SETCOL30 - 1 = MPCR    % SET COL 30                              00685000 D
01B6  4809 0C41 8B30 40F0            B C = B, CSAR          % SET COL 29(DEFAULTS TO SW#2 BEING SET)  00686000 D
01B7  9010 0000 C030 00B0            29 = SAR; 1 = LIT                                                00687000 D
01B8  4809 2C5C 0B30 00F0            LIT OR B = B           % SET BIT 29                              00688000 D
01B9  4809 CC41 8B30 00F0            B C = B, MIR           % RESTORE B                               00689000 D
01BA  05EC 00C0 C030 C040            OUT - 1 = MPCR                                                   00690000 D
01BB  4809 CC41 8B30 40FC  SETCOL30:  B C = B, CSAR                                                   00691000 D
01BC  A010 0003 C030 00B0            30 = SAR; 1 = LIT                                                00692000 D
01BD  4809 2C5C 0B30 00F0            LIT OR B = B           % SET BIT 30                              00693000 D
01BE  4809 CC41 8030 00F0            B C = MIR              % RESTORE B VALUE IN MIR                  00694000 D
01BF  05EC 00C0 0030 0040            OUT - 1 = MPCR                                                   00695000 D
                                                            %                                         00696000 D
                                                            %                                         00697000 D
01C0  4809 2003 0C1C C0F0  TRACE:    LIT = MAR2, BEX        % THIS ROUTINE SETS THE 2 MS BITS IN SR#200698000 D
01C1  022C 00C0 0030 00E0            STATUS2 = LIT          % FOR DUMP REGISTER CALLS TO CRT OR PTR   00699000 D
01C2  4809 0C40 8B30 0CF0            B R = B                % ISOLATE COL. 2 OF CONTROL CARD          00700000 D
01C3  03F0 0003 C000 00A0            16 = SAR; 63 = LIT     % IF 1 THEN SET MS 2 BITS OF SR#2 (CRT)   00701000 D
01C4  4809 2C56 2030 C0F0            LIT AND B = A2         % A2 CONTAINS COL. 2 OF CONTROL CARD      00702000 D
01C5  1000 C0C0 0030 C000            1 = SAR                                                          00703000 D
01C6  4809 C0D2 0030 00F0            A2 EOL 1               % IS COL. 2 A 1?                          00704000 D
01C7  6C19 18C1 C030 C0FC            IF TRUE THEN B101 C = A1; SKIP                                   00705000 D
01C8  4809 18C0 4030 00F0            B10D = A1              % PRINTER MASK                            00706000 D
01C9  046C 0003 0030 C06C            INPUT - 1 = CPCR       % SR#2 INTO B                             00707000 D
01CA  4809 AC5C 0030 00F0            A1 OR B = MIR          % SET MSB OF SR # 2                       00708000 D
01CB  05E0 C0C0 C000 C040            OUT - 1 = MPCR                                                   00709000 D
                                                            %                                         00710000 D
                                                            %                                         00711000 D
                           % * * * * * * * * * * * * AN/UYK-20 EMULATOR * * * * * * * * * * * * * * *00712000 D
                                                            %                                         00713000 D
                                                            %                                         00714000 D
                           % * * * * * * * * * * * * * UTILITY ROUTINES * * * * * * * * * * * * * * *00715000 D
                                                            %                                         00716000 D
                                                            %                                         00717000 D
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                                AEOM:                    % THIS ROUTINE TESTS IF THE :A: FIELD      00719000 D
                                                         % EQUALS THE :M: FIELD.  IF EQUAL LC2 SET00720000 D
                                                         % A2 = RM; B = RA RETURNED                 00721000 D
01CC  3809 0000 0000 00F0                IF LC2                                                     00722000 D
01CD  4809 E000 8000 00F0                A3 R = B                                                   00723000 D
01CE  90F0 0000 0000 0080                4 = SAR; 15 = LIT                                          00724000 D
01CF  4809 2C56 C000 00F0                LIT AND B = B            % B CONTAINS "A" FIELD            00725000 D
01D0  4809 E156 2000 00F0                A3 AND LIT = A2          % A2 CONTAINS "M" FIELD           00726000 D
01D1  4809 CC52 0C00 00F0                A2 EQL B                                                   00727000 D
01D2  5A49 0000 0000 00F0                IF TRUE THEN SET LC2                                       00728000 D
01D3  482D 0000 C000 00F0                JUMP                                                       00729000 D
                                                         %                                          00730000 D
                                                         %                                          00731000 D
01D4  4809 A001 2000 00F0       BUMP:    A1 L = A2                % THIS ROUTINE WILL INCREMENT THE PAR     00732000 D
01D5  0000 0000 0000 0020                COMP 16 = SAR            % TEST FOR WRAPAROUND AND CALL OPCODE     00733000 D
01D6  4809 C000 A000 C0F0                A2 R = A2                % PAR ISOLATED IN LHW OF A2       00734000 D
01D7  4809 C0C0 A000 00F0                A2 + 1 R = A2            % INCREMENT THE COPY OF THE PAR   00735000 D
01D8  4809 C013 0C00 C0F0                A2 GTR 0                 % CHECK FOR WRAPAROUND            00736000 D
01D9  74CB A0C0 4000 00F0                IF FALSE THEN A1 + 1 = A1 ELSE SKIP  % INCREMENT PAR 3Y 1  00737000 D
01DA  029C C000 0C00 0040                OPCODE - 1 = MPCR        % CALL OPCODE FOR NEXT INSTRUCTION 00738000 D
01DB  4809 A000 C000 C0F0                A1 R = A1                % CLEAR OLD PAR                   00739000 D
01DC  0C00 0000 0000 0020                15 = SAR                                                   00740000 D
01DD  4809 A001 4000 C0F0                A1 L = A1                                                  00741000 D
01DE  4809 00C1 0B0C 00F0                1 L = B                  % 1024 INTO B                     00742000 D
01DF  A000 0000 0000 0020                COMP 10 = SAR                                              00743000 D
01E0  4809 AC5C 4000 C0F0                A1 OR B = A1             % SET PAR TO 1024                 00744000 D
01E1  02AC 00C0 0000 C040                OPCODE - 1 = MPCR        % FETCH NEXT INSTRUCTION          00745000 D
                                                         %                                          00746000 D
                                                         %                                          00747000 D
                                BYTETEST:                % THIS INSTRUCTION TEST THE LSB OF B       00748000 D
                                                         % WHICH CONTAINS EITHER (R(M)) OR (R(X)) 00749000 D
                                                         % OR (R(M+1)) AND DIVIDES B BY TWO         00750000 D
                                                         % B CONTAINS RESULT                        00751000 D
                                                         % LC2 = 1 IMPLIES LS BYTE OF Y             00752000 D
                                                         % LC2 = 0 IMPLIES MS BYTE                  00753000 D
01E2  4809 0C40 0000 00F0                B                                                          00754000 D
01E3  5A59 0000 0000 C0F0                IF LST THEN SET LC2; SKIP  % IF LSB OF B EQUALS 1 THEN SET LC2 00755000 D
01E4  3809 00C0 0C00 00FC                IF LC2                   % ELSE CLEAR LC2                  00756000 D
01E5  4809 0C40 8000 00F0                B R = B                  % B DIVIDED BY TWO                00757000 D
01E6  1000 0000 000C C000                1 = SAR                                                    00758000 D
01E7  482D 0000 C00C 00F0                JUMP                                                       00759000 D
                                                         %                                          00760000 D
                                % * * * * * * * * * * * * * CARRY BIT SETTING * * * * * * * * * * * * * * 00761000 D
                                                         %                                          00762000 D
C1E8  2808 0000 0000 C0F0       CARRY:   IF LC1 THEN STEP ELSE SKIP  % THIS ROUTINE WILL SET THE CARRY  00763000 D
C1E9  0280 C000 0C00 C040                SETCARRY - 1 = MPCR      % BIT IF LC1 IS SET UPON ENTRANCE  00764000 D
01EA  02C0 0000 0C0C 004C                CLEARC - 1 = MPCR        % OTHERWISE, CLEAR THE CARRY BIT  00765000 D
                                                         %                                          00766000 D
                                                         %                                          00767000 D
                                CLEARC:                  % THIS ROUTINE CLEARS THE CARRY BIT        00768000 D
                                                         % (POSITION 28) IN PSW                     00769000 D
01EB  4809 A001 C000 00FC                A1 C = A1                                                  00770000 D
01EC  8000 0000 CC00 C030                28 = SAR                                                   00771000 D
01ED  4809 A0CE 4000 40F0                A1 AND B110 = A1,CSAR                                      00772000 D
01EE  4809 AC01 C000 00F0                A1 C = A1                                                  00773000 D
01EF  482D 0000 0000 00F0                JUMP                                                       00774000 D
                                                         %                                          00775000 D
                                                         %                                          00776000 D
C1F0  4809 A0C1 C000 C0F0       SETCARRY:  A1 C = A1             % THIS ROUTINE SETS THE CARRY BIT IN  00777000 D
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01F1  9000 0000 0000 0030            28 = SAR                % BIT POS. 28 IN THE PSW
01F2  4809 A00C 4000 40F0            A1 OR 1 = A1,CSAR
01F3  4809 A0C1 C000 00F0            A1 C = A1
01F4  4820 0000 000C C0F0            JUMP
                                                             %
                     % * * * * * * * * * * * * * END CARRY ROUTINES * * * * * * * * * * * * * *
                                                             %
                     CLEARBUFF:                              %THIS ROUTINE INSERTS SPACES INTO THE
                                                             %PRINT BUFFER (33 WORDS)
01F5  4809 0640 2000 00F0            AMPCR = A2              % SAVE RETURN
01F6  4809 0000 0931 00F0            0 = BC8,LCTR
01F7  01F0 0000 0000 00A0            COMP 16 = SAR;31 = LIT  % REQUIRED FOR BC8
01F8  4809 2000 001C C0F0            LIT = MAR2
01F9  0990 0000 0030 00E0            PRINTBUFF = LIT
01FA  48C9 0C40 0030 00F0            B = MIR                 %SPACES ARE WRITTEN INTO MIR
01FB  020C 0000 0000 0060    PBUFF:  EOUTPUT - 1 = CPCR
01FC  8400 0F46 001E 00F0            IF NOT COV THEN PMAR + 1 = MAR2,INC; STEP ELSE SKIP
01FD  1FA0 0000 0000 0040            PBUFF -1 = MPCR
01FE  4809 C000 0000 00F0            A2 = AMPCR              % RESTORE RETURN
01FF  4809 000D 0000 00F0            STEP                    % DELAY
0200  4820 0000 0000 C0F0            JUMP
                                                             %
                                                             %
                     % * * * * * * * * * * * * CONDITION CODE SETTING* * * * * * * * * * * * *
                                                             %
                                                             %
                     SETCC:                                  % THIS ROUTINE WILL SET THE APPROPRIATE
                                                             % CONDITION CODE IN BITS 24-25 OF THE
                                                             % PSW.  THIS ROUTINE MUST BE PASSED
                                                             % R(A) IN A2 AND R(M) OR (Y) IN B.
0201  4809 CC52 0000 00F0            A2 EOL B                % CHECK IF R(A) = R(M) OR (Y)
0202  6419 CC4C 0000 00F0            IF FALSE THEN A2 XOR B; SKIP
0203  02E0 CC0D 0000 0040            SET00 - 1 = MPCR        % SET 00 CONDITION CODE
0204  4819 000D 0000 00F0            IF MST THEN SKIP        % UNLIKE SIGNS CASE
0205  02FC 0000 0000 0040            LIKE - 1 = MPCR         % LIKE SIGNS CASE
0206  4809 C00D 0000 00F0            A2                      % A2 TO THE ADDER
0207  4808 0000 0000 00FC            IF MST THEN STEP ELSE SKIP  % MST -> A2 WAS NEGATIVE
0208  0300 0000 0000 C040            SET11 - 1 = MPCR        % SET 11 CONDITION CODE
0209  031C 0000 C000 C040            SET01 - 1 = MPCR        % A2 POSITIVE, B NEGATIVE
020A  48C9 CC58 0000 C0F0    LIKE:   A2 GTR B                % LIKE SIGNS CASE
020B  78CB 0000 000C 00F0            IF TRUE THEN STEP ELSE SKIP
020C  0320 000D 0C00 0040            SET01 - 1 = MPCR        % A2 > B
020D  0330 00C0 0C00 0040            SET11 - 1 = MPCR        % A2 < B
                                                             %
                                                             %
                     SETCCA:                                 % THIS ROUTINE TESTS THE CONTENTS OF THE
                                                             % DATA IN B WHICH IS THE RESULT OF AN
                                                             % ARITHMETIC INSTRUCTION
                                                             % B CAN BE 16 OR 32 BITS LC1 SET = 32
020E  2819 0000 0C0C 00F0            IF LC1 THEN SKIP        % TEST FOR DOUBLE WORD COMPARE
020F  4809 CC41 0800 00F0            B L = B
0210  DC00 0000 0000 C020            COMP 16 = SAR           % PREPARE SHIFT AMOUNT
0211  4809 0C52 0000 C0F0            B EOL 0
0212  6419 CC40 0C00 D0F0            IF FALSE THEN B; SKIP   % SKIP IF NON-ZERO
0213  0340 0000 0000 0040            SET00 - 1 = MPCR
0214  4819 000D C000 00FC            IF MST THEN SKIP        % CHECK FOR NEGATIVE VALUE
0215  035C 000D 0000 0040            SET01 - 1 = MPCR
0216  0360 C00D 0000 C040            SET11 - 1 = MPCR
                                                             %
                                                             %
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0217  4809 18C1 8800 00F0   SET11:   B101 C = B              % DEFAULT TO (R(A)) < (R(M)) OR (Y)       00838000 D
                                                             % ARITHMETIC TEST < 0 (NEG)               00839000 D
0218  000C 0000 0000 0010            B = SAR                                                           00840000 D
0219  2809 0000 0000 00F0            IF LC1                  % JUST TO CLEAR FLAG SET IN SETCC         00841000 D
021A  4809 AC5C 4000 00F0            B OR A1 = A1                                                      00842000 D
021B  4820 0000 0000 00F0            JUMP                                                              00843000 D
                                                             %                                         00844000 D
                                                             %                                         00845000 D
                            SET00:                           % THIS ROUTINE WILL SET CONDITION CODE 00 00846000 D
                                                             % IN BITS 24-25 OF THE PSW                00847000 D
                                                             % ARITHMETIC TEST 0                       00848000 D
021C  4809 1809 8800 00F0            B010 C = B                                                        00849000 D
021D  0000 0000 0000 0010            B = SAR                                                           00850000 D
021E  4809 AC55 4000 00F0            B AND A1 = A1                                                     00851000 D
021F  4820 0000 0000 00F0            JUMP                                                              00852000 D
                            SET01:                           % THIS ROUTINE WILL SET CONDITION CODE 01 00853000 D
                                                             % IN BITS 24-25 OF THE PSW                00854000 D
                                                             % ARITHMETIC TEST > 0 (POS)               00855000 D
0220  4809 1800 8800 00F0            B100 R = B                                                        00856000 D
0221  000C 0000 0000 0010            B = SAR                                                           00857000 D
0222  4809 AC5C 4000 00F0            B OR A1 = A1                                                      00858000 D
0223  4809 1819 8800 00F0            B011 C = B                                                        00859000 D
0224  3C00 0C00 0000 0000            7 = SAR                                                           00860000 D
0225  4809 AC55 4000 00F0            B AND A1 = A1                                                     00861000 D
0226  4820 0000 0000 00F0            JUMP                                                              00862000 D
                                                             %                                         00863000 D
                                                             %                                         00864000 D
                            CHECKCC:                         % THIS ROUTINE WILL RETURN THE 2 COND     00865000 D
                                                             % CODE BITS IN THE LS 2 BITS OF B         00866000 D
0227  4809 A001 C000 40F0            A1 C = A1, CSAR         % SHIFT CC BITS TO LS 2 BIT POS.          00867000 D
0228  9030 0000 0000 00A0            23 = SAR; 3 = LIT                                                 00868000 D
0229  4809 A156 0800 00F0            A1 AND LIT = B          % ISOLATE CC BITS IN B                    00869000 D
022A  4809 A001 C000 00F0            A1 C = A1               % RESTORE A1                              00870000 D
022B  4820 0000 0000 00F0            JUMP                                                              00871000 D
                                                             %                                         00872000 D
                            % * * * * * * * * * * END CONDITION CODE ROUTINES* * * * * * * * * * * * * 00873000 D
                                                             %                                         00874000 D
                            CONTENTSRA:                      % THIS ROUTINE GETS (R(A)) IN B.  IT      00875000 D
                                                             % ASSUMES THE INSTRUCTION IS IN B. THE    00876000 D
                                                             % ADDRESS OF R(A) RETURNED IN MS WORD A3  00877000 D
022C  4809 0640 2000 00F0            AMPCR = A2              % SAVE RETURN ADDRESS                     00878000 D
022D  4809 0C40 8800 00F0            B R = B                 % INSTRUCTION IS PASSED IN B              00879000 D
022E  80F0 0000 0000 0080            4 = SAR; 15 = LIT                                                 00880000 D
022F  4809 2C56 0800 00F0            LIT AND B = B           % ISOLATE THE "A" FIELD                   00881000 D
0230  0370 0000 0000 0060            REGSTACK - 1 = CFCR                                               00882000 D
0231  4809 0000 0000 24F0            ASE                                                               00883000 D
0232  4809 0F40 0800 00F0            BMAR = B                % PUT ADDRESS OF R(A) INTO B              00884000 D
0233  4809 0C41 0800 00F0            B L = B                 % MOVE ADDR OF R(A) TO MS WORD            00885000 D
0234  0000 0000 0C00 0020            COMP 16 = SAR                                                     00886000 D
0235  4809 EC5C 1000 00F0            B OR A3 = A3            % UPPER WORD OF A3 HAS ADDR OF R(A)       00887000 D
0236  0380 0000 0000 0060            EINPUT - 1 = CPCR       % (R(A)) IS IN B                          00888000 D
0237  4809 C000 0030 00F0            A2 = AMPCR              % RESTORE RETURN ADDRESS                  00889000 D
0238  4820 0000 0000 00F0            JUMP                                                              00890000 D
                                                             %                                         00891000 D
                                                             %                                         00892000 D
                            CONTENTSRM:                      % THIS ROUTINE GETS (R(M)) IN B.  IT      00893000 D
                                                             % ASSUMES THE INSTRUCTION IS IN A3.       00894000 D
0239  4809 0640 2000 00F0            AMPCR = A2              % SAVE THE RETURN ADDRESS                 00895000 D
023A  4809 E156 0800 00F0            A3 AND LIT = B                                                    00896000 D
023B  00FC 0000 0000 00E0            15 = LIT                                                          00897000 D
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023C  039C 0003 003C 0060            REGSTACK - 1 = CPCR                                    00898000 D
023D  03A0 C000 003C 0060            EINPUT - 1 = CPCR        % (R(M)) INTO B               00899000 D
023E  4809 C000 CC4C 00F0            A2 = AMPCR                                             00900000 D
023F  4809 0003 0000 00F0            STEP                                                   00901000 D
0240  482D 0000 0000 00F0            JUMP                                                   00902000 D
                                                              %                             00903000 D
                                                              %                             00904000 D
                           DIV:                               % THIS ROUTINE WILL DIVIDE A2/B, AND      00905000 D
                                                              % THE QUOTIENT IS RETURNED IN A3, REM IN  00906000 D
                                                              % A2. ALL NUMBERS MUST BE LEFT JUSTIFIED  00907000 D
                                                              % LC1 MUST BE SET FOR REG PAIR DIVIDEND   00908000 D
0241  4809 CC4C 0030 00F0            A2 XOR B                                               00909000 D
0242  4A49 0C40 0000 C0FC            B; IF MST THEN SET LC2  % NEG QUOTIENT FLAG             00910000 D
0243  4C09 0C5E 0B30 C0F0            IF MST THEN -B = B  % COMPLEMENT B                     00911000 D
0244  4809 0C43 8030 00F0            B R = B                                                00912000 D
0245  0000 C000 000C 0020            16 = SAR                                               00913000 D
0246  4809 C0C0 0030 C0F0            A2                                                     00914000 D
0247  4C0B C0C2 2000 00F0            IF MST THEN NOT A2 = A2;STEP ELSE SKIP                 00915000 D
0248  4809 C000 2030 C0F0            A2 + 1 = A2              % TWO:S COMPLEMENT            00916000 D
0249  2409 CC00 A000 00F0            IF NOT LC1 THEN A2 R = A2  % RIGHT JUSTIFY FOR 16 BITS  00917000 D
024A  2809 0003 1000 00F0            0 = A3; IF LC1                                         00918000 D
024B  4809 0C52 0030 00F0            C EOL B                                                00919000 D
024C  680B 0CC0 003C 00F0            IF TRUE THEN STEP ELSE SKIP  % CHECK FOR ZERO DIVISOR  00920000 D
024D  030C 0C00 0030 0040            OVERFLOW - 1 = MPCR                                    00921000 D
024E  4809 0000 0031 24F0            LCTR; ASE                % SET UP CTR FOR 30 ITERATIONS 00922000 D
024F  01E0 0000 0000 00E0            30 = LIT                                               00923000 D
0250  4809 0003 1010 00FC            0 = A3, BR2              % CLEAR TRIAL DIVIDEND        00924000 D
0251  4809 0C43 001C 00F0            B = MAR2                 % DIVISOR INTO BMAR           00925000 D
0252  4809 00C0 0B30 00F0            0 = B                    % CLEAR PARTIAL QUOTIENT      00926000 D
0253  4809 CF5E 0030 0CF0            A2 LSS BMAR              % QUOTIENT = 0                00927000 D
0254  740B 0000 1030 00F0            IF TRUE THEN 0 = A3; STEP ELSE SKIP                    00928000 D
0255  03C0 C003 0030 C040            ZQUO - 1 = MPCR                                        00929000 D
0256  4809 C001 2000 00F0            A2 L = A2                % SHIFT OFF MSB (ZERO)        00930000 D
0257  900C 0CC0 003C C030            COMP 1 = SAR                                           00931000 D
0258  4809 C0C0 0030 00F0  DIV1:     A2                       % BRING DIVIDEND TO THE ADDER 00932000 D
0259  4C09 E00C 1C3C 00FC            IF MST THEN A3 OR 1 = A3  % BUILD TRIAL DIVIDEND        00933000 D
025A  4809 C0C1 2032 00F0            A2 L = A2, INC           % PREPARE NEXT MSB IN DIVIDEND 00934000 D
025B  300C 0000 0030 0030            COMP 1 = SAR                                           00935000 D
025C  4809 EF5E 0C30 00FC            A3 GEQ BMAR              % CHECK IF TRIAL DIVIDEND >= DIVISOR  00936000 D
025D  780B 0003 0030 0CF0            IF TRUE THEN STEP ELSE SKIP                            00937000 D
025E  03D0 00C3 0000 004C            ONET - 1 = MPCR                                        00938000 D
025F  4809 0C41 0830 00FC            B L = B                  % PUT ZERO IN PARTIAL QUOTIENT 00939000 D
0260  900C 00C0 0C30 C030            COMP 1 = SAR                                           00940000 D
0261  03E0 C000 0000 004C            DIV2 - 1 = MPCR                                        00941000 D
0262  4809 EF5E 1030 00F0  ONET:     A3 - BMAR = A3           % TRIAL DIVIDEND - DIVISOR    00942000 D
0263  4809 0300 0030 C0FC            STEP                                                   00943000 D
0264  4809 0C41 0B3C 00FC            B L = B                                                00944000 D
0265  3010 00C0 0000 00B0            1 = LIT; COMP 1 = SAR                                  00945000 D
0266  4809 2C5C 0800 00FC            LIT OR B = B             % PUT 1 IN THE PARTIAL QUOTIENT 00946000 D
0267  4809 E301 1000 00F0  DIV2:     A3 L = A3                % PREPARE FOR NEXT DIGIT IN TRIAL DIVIDN 00947000 D
0268  9000 0000 C03C 003C            COMP 1 = SAR                                           00948000 D
0269  900B 0000 0000 00F0            IF NOT COV THEN STEP ELSE SKIP                         00949000 D
026A  2570 0003 000C 0040            DIV1 - 1 = MPCR                                        00950000 D
026B  4809 E0C0 AC00 00F0            A3 R = A2                % REMAINDER INTO A2           00951000 D
026C  1000 0000 C030 000C            1 = SAR                                                00952000 D
026D  4809 0C40 1000 00F0            B = A3                   % QUOTIENT INTO A3            00953000 D
026E  4809 E003 8B3C C0F0            A3 R = B                 % EXAMINE UHW OF QUOTIENT     00954000 D
026F  000C 0000 003C 0020            16 = SAR                                               00955000 D
0270  4809 E001 1C00 00F0            A3 L = A3                % CLEAR UHW OF THE QUOTIENT   00956000 D
0271  4809 E003 900C 00F0            A3 R = A3                % RIGHT JUSTIFY QUOTIENT      00957000 D
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0272 4809 00C3 00?? 00FC            0 = BR2                                              00958C00 D
0273 4809 0C52 0030 00FC            0 EQL B               % CHECK FOR A 16 BIT QUOTIENT      00959C00 D
0274 63C9 0000 0030 00F0            IF FALSE THEN SET LC1                                    00960C00 D
0275 3C00 E002 1000 00F0            IF LC2 THEN NOT A3 = A3; STEP ELSE JUMP  % LC2 = NEG QUOT.  00961C00 D
0276 4809 E0C3 1000 C0F0            A3 + 1 = A3           % COMPLEMENT QUOTIENT              00962C00 D
0277 4809 E0C1 1030 00F0            A3 L = A3             % CLEAR UHW OF QUOTIENT            00963C00 D
0278 000C 0000 0000 0020            COMP 16 = SAR                                            00964C00 D
0279 4809 E0C0 9C30 C0F0            A3 R = A3             % RIGHT JUSTIFY QUOTIENT           00965C00 D
027A 4809 C0C2 2C00 C0F0            NOT A2 = A2           % COMPLEMENT REMAINDER             00966C00 D
027B 48C9 C0C1 2030 00F0            A2 + 1 L = A2         % CLEAR UHW OF REMAINDER           00967C00 D
027C 482D C000 A000 C0FC            A2 R = A2; JUMP       % RIGHT JUSTIFY REMAINDER          00968C00 D
027D 3C0D C0C2 203C 00F0   ZQUO:    IF LC2 THEN  NOT A2 = A2; STEP ELSE JUMP                 00969C00 D
027E 482D C0C0 2C0C 00FC            A2 + 1 = A2; JUMP                                        00970C00 D
                                                          %                                  00971000 D
                           % * * * * * * * * * * * * * * * * DEBUGGER * * * * * * * * ** * * * * * * * 00972C00 D
                                                          %                                  00973C00 D
                           DUMPREG:                       % THIS ROUTINE WILL DUMP OUT THE   00974C00 D
                                                          % EMULATOR:S MAIN MEMORY MAPPING THROUGH 00975000 D
                                                          % THE RTC ADDR AND THE FOLLOWING   00976C00 D
                                                          % D-MACHINE REGISTERS:  AMPCR, A1, A2,  00977C00 D
                                                          % A3, MIR, AND BR1                 00978C00 D
027F 4809 0000 0D3C 00F0            CMI                   % SAVE MIR IN B REGISTER           00979C00 D
0280 4809 0640 0030 C0FC            AMPCR = MIR           % SAVE AMPCR                       00980C00 D
0281 4809 2003 001C C0F0            LIT = MAR2                                               00981C0C D
0282 0260 0003 0C00 C0E0            WORKSPACE = LIT                                          00982C00 D
0283 03F0 00C0 000C 0060            EOUTPUT - 1 = CPCR    % WRITE AMPCR INTO WORKSPACE       00983C00 D
0284 4809 0F45 0C1C C0F0            BMAR + 1 = MAR2                                          00984C00 D
0285 4809 ACC0 003C 00F0            A1 = MIR                                                 00985C0C D
0286 040C 00C0 0C0C 006C            EOUTPUT - 1 = CPCR    % WRITE A1 INTO WORKSPACE + 1      00986C00 D
0287 4809 0F45 0C1C C0F0            BMAR + 1 = MAR2                                          00987C00 D
0288 4009 CC03 0030 00FC            A2 = MIR                                                 00988C00 D
0289 041C 0000 0C00 0060            EOUTPUT - 1 = CPCR    % WRITE A2 INTO WORKSPACE + 2      00989C0C D
028A 4809 0F46 001C 00F0            BMAR + 1 = MAR2                                          00990C00 D
028B 4809 E003 0C30 00F0            A3 = MIR                                                 00991000 D
028C 0420 0000 0030 0060            EOUTPUT - 1 = CPCR    % WRITE A3 INTO WORKSPACE + 3      00992C00 D
028D 4809 0F45 001C C0F0            BMAR + 1 = MAR2                                          00993C00 D
028E 4809 0C40 0030 00F0            B = MIR                                                  00994C00 D
028F 0430 00C0 0000 0060            EOUTPUT - 1 = CPCR    % WRITE MIR INTO WORKSPACE + 4     00995C00 D
0290 4809 0F45 001C C0FC            BMAR + 1 = MAR2                                          00996C00 D
0291 4809 00C0 0030 20FC            ASR                   % REFERENCE BR1                    00997000 D
0292 48C9 0F40 8C30 C0F0            BMAR R = MIR                                             00998C00 D
0293 0000 0000 0030 C010            8 = SAR                                                  00999C00 D
0294 0440 0000 0000 C06C            EOUTPUT - 1 = CPCR    % WRITE BR1 INTO WORKSPACE + 5     01000000 D
0295 4809 23C0 1000 C0FC            LIT = A3              % A3 HOLDS READ ADDR               01001C00 D
0296 000C 0000 0030 00B0            GREG1 = LIT; COMP 8 = SAR                                01002C0C D
0297 4809 2001 0C20 00F0            LIT L = BR1           % USE BR1 AS HOLDER OF READ ADDRESS   01003C00 D
0298 1F4C C0C0 003C C060   NEXTEIGHT:  CLEARBUFF - 1 = CPCR  % CLEAR PRINTBUFF               01004C00 D
0299 4809 EC03 0C1C C0F0            A3 = MAR2             % SET UP READ ADDRESS              01005C00 D
029A 4809 20C3 4030 00F0            LIT = A1              % PRINTBUFF ADDR TO BE WRITTEN INTO   01006C0C D
029B 099C 0003 0000 00E0            PRINTBUFF = LIT                                          01007C00 D
029C 0450 0000 000C 006C   NEXTREG: EINPUT - 1 = CPCR     % READ THE CONTENTS OF A GENERAL REG  01008C0C D
                                                          % INTO THE B REGISTER              01009C00 D
029D 4809 0F41 002C C0F0            BMAR L = BR1                                             01010C0C D
029E 00C0 0CC0 0000 0030            COMP 8 = SAR                                             01011C0C D
029F 4809 0C41 9001 C0F0            B C = A3, LCTR        % PUT B INTO A3, INTERCHANGE MS 16 BITS  01012C00 D
02A0 0070 00C3 0C00 C0A0            16 = SAR; 7 = LIT     % AND LS 16 BITS                   01013C00 D
02A1 4809 0003 0B3C C0F0            0 = MIR,B             % CLEAR MIR AND B                  01014C00 D
02A2 2809 E155 2000 00F0   NEXTDIGIT:  A3 AND LIT = A2; IF LC1  % A2 CONTAINS LS 4 BITS OF A REG   01015C00 D
02A3 30F0 0000 0000 0080            15 = LIT ; 4 = SAR                                       01016C0C D
02A4 48C9 E0C0 900C C0F0            A3 R = A3             % SHIFT A3 RIGHT TO POSITION NEXT 4 BITS 01017C0C D
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02A5  4809 C158 0030 00FC        A2 GTR LIT              % CHECK IF 4 DIGIT HEX VALUE IS A-F       01018000 D
02A6  009C 0003 0030 00EC        9 = LIT                                                           01019000 D
02A7  7C0B C140 2C30 00F0        IF TRUE THEN A2 + LIT = A2; STEP ELSE SKIP  % ADD 7 FOR BCL      01020000 D
02A8  0070 0003 0C00 00E0        7 = LIT                                                           01021000 D
02A9  4809 CC41 8030 00F0        A2 + B C = B            % PLACE 4 DIGIT VALUE INTO B( HEX WORD)   01022000 D
02AA  0000 0000 0030 0010        8 = SAR                                                           01023000 D
02AB  4809 0C40 0030 00F0        B = MIR                                                           01024000 D
02AC  4809 0B02 8B02 C0F0        NOT CTR R = B, INC      % USE B TO CHECK COUNTER VALUE            01025000 D
02AD  0040 0000 0030 00B0        24 = SAR; 4 = LIT                                                 01026000 D
02AE  4809 A003 001C 00F0        A1 = MAR2               % PROPER WRITE ADDRESS                    01027000 D
02AF  4809 2C52 0C30 C0F0        LIT EOL B               % TEST COUNTER FOR 4 ITERATIONS           01028000 D
02B0  6BCB 0C03 0C30 C0F0        IF TRUE THEN SET LC1; STEP ELSE SKIP  % TRUE MEANS HALFWORD      01029000 D
02B1  0460 00C0 0030 C060        EOUTPUT - 1 = CPCR      % COMPLETED-WRITE IT INTO MEMORY          01030000 D
02B2  2FC9 A0C0 4C30 00F0        IF LC1 THEN SET LC1; A1 + 1 = A1 % INCREMENT PRINTBUFF ADDR      01031000 D
02B3  2FC9 0000 0030 00F0        IF LC1 THEN SET LC1; 0 = B  % CLEAR B FOR NEXT HALFWORD          01032000 D
02B4  280B 0000 003C 00F0        IF LC1 THEN STEP ELSE SKIP  % 16 BITS OF THE GIVEN REGISTER      01033000 D
02B5  2A1C 00C0 0000 004C        NEXTDIGIT - 1 = MPCR    %HAVE BEEN CONVERTED TO BCL FORMAT        01034000 D
02B6  4809 0000 C030 00F0        BMI                     % RESTORE PARTIAL B CONSTRUCT             01035000 D
02B7  800D 0000 C00C C0F0        IF NOT COV THEN STEP ELSE SKIP                                    01036000 D
02B8  2A1C C0C0 0000 0040        NEXTDIGIT - 1 = MPCR    % LOOP DONE 8 TIMES FOR 32 BITS OF EACH   01037000 D
                                                         % GENERAL REGISTER                        01038000 D
02B9  4809 A003 0C1C 00F0        A1 = MAR2               % PREPARE TO WRITE OUT LAST HALFWORD      01039000 D
02BA  0470 00C3 003C 0060        EOUTPUT - 1 = CPCR      % AT THIS POINT, A FULL REG IS DONE       01040000 D
02BB  4809 00C0 0030 20FC        ASR                     % REFERENCE BR1                           01041000 D
02BC  4809 0F40 9000 00F0        BMAR R = A3             % RESTORE OLD READ ADDRESS IN A3          01042000 D
02BD  000C 0000 003C C010        8 = SAR                                                           01043000 D
02BE  4809 E0C3 1030 C0F0        A3 + 1 = A3             % SET UP NEXT READ ADDRESS                01044000 D
02BF  4809 E152 0030 C0F0        A3 EOL LIT                                                        01045000 D
02C0  008C 0003 0030 00EC        8 = LIT                                                           01046000 D
02C1  6BCB E152 0C30 00F0        A3 EOL LIT; IF TRUE THEN SET LC1;STEP ELSE SKIP                   01047000 D
02C2  0480 0000 003C 0060        WRITEBUFF - 1 = CPCR                                              01048000 D
02C3  01C0 0003 003C 00E0        16 = LIT                                                          01049000 D
02C4  6BCB E152 0C30 00F0        A3 EOL LIT; IF TRUE THEN SET LC1;STEP ELSE SKIP                   01050000 D
02C5  0490 0000 0000 006C        WRITEBUFF - 1 = CPCR                                              01051000 D
02C6  0180 0003 000C C0E0        24 = LIT                                                          01052000 D
02C7  6BCB E152 0000 C0F0        A3 EOL LIT; IF TRUE THEN SET LC1;STEP ELSE SKIP                   01053000 D
02C8  04A0 0003 003C 0060        WRITEBUFF - 1 = CPCR                                              01054000 D
02C9  020C 0003 003C 00E0        32 = LIT                                                          01055000 D
02CA  6BCB E152 0000 00F0        A3 EOL LIT; IF TRUE THEN STEP; SET LC1 ELSE SKIP                  01056000 D
02CB  04BC 0000 0030 C060        WRITEBUFF - 1 = CPCR                                              01057000 D
02CC  028C 00C3 003C C0EC        40 = LIT                                                          01058000 D
02CD  6BCB E152 0030 C0F0        A3 EOL LIT; IF TRUE THEN STEP; SET LC1 ELSE SKIP                  01059000 D
02CE  04C0 0003 0C30 0060        WRITEBUFF - 1 = CPCR                                              01060000 D
02CF  4809 E003 0C1C 00F0        A3 = MAR2               % MAR2 CONTAINS ADDRESS OF NEXT REG.      01061000 D
02D0  280B C000 0000 00F0        IF LC1 THEN STEP ELSE SKIP  % ARE ARE WE FINISHED WITH ONE LINE01062000 D
02D1  297C C003 0030 C04C        NEXTEIGHT - 1 = MPCR                                              01063000 D
02D2  4809 A140 403C 00FC        A1 + LIT = A1           % PUT SPACE BETWEEN REGISTER VALUES       01064000 D
02D3  0020 0000 003C 00E0        2 = LIT                                                           01065000 D
02D4  4809 E158 0030 00F0        A3 LEQ LIT              % CHECK IF ALL REG HAVE BEEN DUMPED       01066000 D
02D5  02F0 0003 0C00 00E0        47 = LIT                % CURRENTLY, ROUTINE IS SET FOR 48 REGS   01067000 D
02D6  700B 0003 0000 00F0        IF TRUE THEN STEP ELSE SKIP                                       01068000 D
02D7  298C 00C3 C03C 0040        NEXTREG - 1 = MPCR      % READ ANOTHER REGISTER                   01069000 D
02D8  040C 0000 CC30 0060        WRITEBUFF - 1 = CPCR    % PRINT OUT LAST 8 REGISTERS              01070000 D
02D9  1F4C 00C0 0C30 006C        CLEARBUFF - 1 = CPCR    % CLEAR THE PRINT BUFFER                  01071000 D
02DA  04EC 00C3 0C00 0060        WRITEBUFF - 1 = CPCR    % JUST TO CREATE A BLANK LINE             01072000 D
02DB  04F0 00C0 C030 C060        WRITEBUFF - 1 = CPCR    % JUST TO CREATE A BLANK LINE             01073000 D
02DC  050C 0003 0C3C C060        WRITEBUFF - 1 = CPCR    % JUST TO CREATE A BLANK LINE             01074000 D
02DD  0510 0000 0C30 0060        WRITEBUFF - 1 = CPCR    % JUST TO CREATE A BLANK LINE             01075000 D
02DE  4809 20C3 001C 00FC        LIT + 1 = MAR2          % LOAD THE ADDRESS OF A1 INTO MAR2        01076000 D
02DF  0260 0C00 0030 C0E0        WORKSPACE = LIT                                                   01077000 D
```

```
02E0  052C 0000 0000 0060            EINPUT - 1 = CPCR        % READ IN CONTENTS OF A1
02E1  4809 0C40 4000 C0F0            B = A1                   % RESTORE A1
02E2  4809 0F46 C01C 00F0            BMAR + 1 = MAR2          % CONSTRUCT ADDRESS OF A2
02E3  0530 0000 0030 0060            EINPUT - 1 = CPCR        % READ IN A2
02E4  4809 0C40 2030 C0F0            B = A2                   % RESTORE A2
02E5  4809 0F46 001C C0F0            BMAR + 1 = MAR2          % CONSTRUCT ADDRESS OF A3
02E6  0540 0000 0030 0060            EINPUT - 1 = CPCR        % READ IN A3
02E7  4809 CC40 1030 00F0            B = A3                   % RESTORE A3
02E8  4809 0F46 0C1C 00F0            BMAR + 1 = MAR2          % CREATE ADDR OF MIR(WORKSPACE + 4)
02E9  0550 0000 0000 0060            EINPUT - 1 = CPCR        % READ IN MIR
02EA  4809 0C40 0030 00F0            B = MIR                  % RESTORE MIR
02EB  4809 0F45 001C 00F0            BMAR + 1 = MAR2          % CREATE ADDR OF BP1
02EC  0560 00C0 0000 0060            EINPUT - 1 = CPCR
02ED  4809 0C41 0020 00F0            B L = BR1                % RESTORE ER1
02EE  0260 0000 0000 C0B0            COMP B = SAR ; WORKSPACE = LIT
02EF  4809 2003 001C 00F0            LIT = MAR2               % PUT ADDRESS OF AMPCR IN MAR2
02F0  0570 0000 0030 0060            EINPUT - 1 = CPCR        % READ IN OLD AMPCR
02F1  4809 0C40 0090 00F0            B = AMPCR                % RESTORE OLD AMPCR
02F2  4809 0000 0000 00F0            STEP
02F3  4820 00C0 0000 00F0            JUMP
                                                              %
                                                              %
                          EINPUT:                             % THIS ROUTINE READS THE CONTENT OF THE
                                                              % MEMORY ADDRESS IN MAR2
02F4  A809 0000 0000 0CF0            MR2; IF ROC              % PERFORM READ
02F5  AC28 00C0 0C00 00F0            WHEN ROC THEN BEX; JUMP    % READ CONTENTS OF MAR2 INTO B
                                                              %
                                                              %
                          EOUTPUT:                            % THIS ROUTINE WRITES MIR INTO THE
                                                              % MEMORY ADDRESS OF MAR2
02F6  9809 0000 0C00 1CF0            MW2; IF SAI              % MEMORY WRITE
02F7  9C28 0000 0000 0CF0            WHEN SAI THEN 0; JUMP  % WHEN WRITE COMPLETED JUMP
                                                              %
                                                              %
                          EXTIO:                              % THIS ROUTINE DOES EXTERNAL I/O
                                                              % INTERFACE BETWEEN THE UYK20 EMULATION
                                                              % AND THE IOP.  B CONTAINS THE CONTENTS
                                                              % OF MAILBOX - 1  IF REQUIRED.
02F8  1C88 0013 0C1C 00F0            SET GC2; WHEN GC2 THEN B111=MAR2
02F9  9809 0003 001C 1CF0            MW2; B110=MAR2; IF SAI
02FA  9C08 CC40 0030 C0F0            WHEN SAI THEN B = MIR
02FB  4809 C013 001C 1CF0            B111 = MAR2; MW2         % WRITE B INTO MAILBOX - 1
02FC  9B08 0C00 0C00 C0F0            WHEN SAI THEN SET INT
02FD  D008 00C0 CC0C C0F0            WHEN NOT INT THEN STEP
02FE  DEC8 C000 0C0C 0CF0            WHEN INT THEN BEX; MR2
02FF  AEC8 0C42 0000 00F0            WHEN ROC THEN NOT B; RESET GC2
0300  682F 00C0 C00C 00F0            IF ABT THEN JUMP ELSE RETN
                                                              %
                                                              %
                          FAULT:                              % THIS ROUTINE PRINTS OUT THE ERROR
                                                              % MESSAGE "FAULT INTERRUPT"
                                                              % INSERTED BY LOADER JCL AND STOPS THE
                                                              % MACHINE
0301  0580 0C00 0000 006C            SAVEREG - 1 = CPCR
0302  4809 0641 0C20 C0F0            AMPCR L = OR1
0303  0CE0 0000 C000 C0CC            ERRORLIST = AMPCR        % CREATE ERRORLIST ADDRESS IN BR1
0304  000C 0000 0000 0030            COMP B = SAR
0305  0590 0CC0 000C C040            PRTERR - 1 = MPCR
                                                              %
                                                              %
```

```
% * * * * * * * INPUT OUTPUT CONTROLLER * * * * * * * * * * * * * * * * * 01138000 D
                                               %                                  01139000 D
          COMPRES:                             % THIS ROUTINE COMPRESSES AN/UYK20 01140000 D
                                               % 16 BIT BUFFERS (LHW OF 32 BIT BURROUGHS01141000 D
                                               % S-MEMORY WORD) INTO A 32 BIT WORD     01142000 D
                                               % FORMAT COMPATIBLE WITH THE IOP        01143000 D
                                               % UPON ENTRY, BR1 CONTAINS BUFFER ADDRESS01144000 D
                                               % NO. OF BUFFERS IN UHW OF A3           01145000 D
                                               % THIS ROUTINE ACCEPTS A VARIABLE       01146000 D
                                               % BUFFER LENGTH FOR CRT OUTPUT, 33 WORDS 01147000 D
                                               % FOR PRT OUTPUT                        01148000 D
0306 4809 0640 0C90 00F0      AMPCR = MIR             % STORE AMPCR INTO STACK              01149000 D
0307 4809 2000 001C 00F0      LIT = MAR2                                                    01150000 D
0308 02C0 0000 0000 00E0      STACK = LIT                                                   01151000 D
0309 2F50 00C0 C000 C060      EOUTPUT - 1 = CPCR      % (STACK) = AMPCR                     01152000 D
030A 4809 0000 0000 20F0      ASR                     % REFERENCE BR1                       01153000 D
030B 4809 0F40 0010 C0F0      BMAR = BR2              % STORE BUFFER ADDRESS IN BR2         01154000 D
030C 4809 E000 9000 C0F0      A3 R = A3               % CLEAR LHW OF A3 FOR COUNT           01155000 D
030D 0000 0000 0000 002C      15 = SAR                                                      01156000 D
030E 4809 E0C1 1000 00F0      A3 L = A3                                                     01157000 D
030F 05AC C0C0 0000 C060 COMRPT: EMULIN - 1 = CPCR    % GET CONTENTS OF BUFFER ADDRESS WORD 01158000 D
0310 4809 0C41 2020 00F0      B L = A2                % STORE CONTENTS IN UHW OF A2         01159000 D
0311 000C 0000 0000 0020      COMP 16 = SAR                                                 01160000 D
0312 4809 0F47 0010 00F0      BMAR + 1 L = BR2        % GET ADJACENT WORD ADDR.             01161000 D
0313 0000 0000 0C00 0030      COMP 8 = SAR                                                  01162000 D
0314 058C 0000 0000 C060      EMULIN - 1 = CPCR       % B = CONTENTS OF ADJACENT WORD       01163000 D
0315 4809 CC5C 0090 C0F0      A2 OR B = MIR           % COMBINED INTO ONE 32 BIT WORD       01164000 D
0316 4809 0F46 0B30 00F0      BMAR + 1 = B            % STORE NEXT WORD PAIR ADDR. IN B     01165000 D
0317 4809 0000 0000 20FC      ASR                     % REFERENCE BR1                       01166000 D
0318 4809 0F40 801C 40F0      BMAR R = MAR2,CSAR      % COMPRESSED WORD DESTINATION         01167000 D
0319 000C 00C0 0000 001C      8 = SAR                                                       01168000 D
031A 4809 CC41 0020 00F0      B L = BR1               % STORE WORD PAIR ADDR. IN B          01169000 D
031B 4809 C000 0030 24F0      ASE                     % REFERENCE BR2                       01170000 D
031C 4809 0F41 0010 00F0      BMAR L = BR2            % COMPRESSED WORD DESTINATION IN BR2  01171000 D
031D 05CC C000 0000 0060      EMULOUT - 1 = CPCR                                            01172000 D
031E 4809 0F40 2000 00F0      BMAR = A2               % SAVE DESTINATION ADDR. IN B         01173000 D
031F 4809 2000 001C 00F0      LIT + 1 = MAR2          % BUFFER LENGTH IN IOCW + 2           01174000 D
0320 032C 0000 0000 00E0      IOCW = LIT                                                    01175000 D
0321 4809 0F46 0C1C 00F0      BMAR + 1 = MAR2         % IOCW + 2 = MAR2                     01176000 D
0322 2F30 0000 C000 0060      EINPUT - 1 = CPCR       % B = BUFFER LENGTH                   01177000 D
0323 4809 0000 0000 20F0      ASR                     % REFERENCE BR1                       01178000 D
0324 4809 0F40 CC10 00F0      BMAR = BR2              % TRANSFER NEXT WORD PAIR ADDR TO BR2 01179000 D
0325 4809 CCC1 0020 00F0      A2 + 1 L = BR1          % NEXT DESTINATION ADDR. IN BR1       01180000 D
0326 0000 0000 0000 0030      COMP 8 = SAR                                                  01181000 D
0327 4909 E0C0 1000 00F0      A3 + 1 = A3             % INCREMENT COUNTER ( < 2 16 - 1)     01182000 D
0328 4809 E001 2000 00F0      A3 L = A2               % ISOLATE COUNTER IN A2               01183000 D
0329 021C 0000 0000 00AC      COMP 16 = SAR; 33 = LIT                                       01184000 D
032A 4809 CCC0 A000 00F0      A2 R = A2                                                     01185000 D
032B 3E59 CC52 0000 00FC      IF LC2 THEN A2 EQL B; SET LC2; SKIP                           01186000 D
032C 4809 C152 0000 C0F0      A2 EQL LIT                                                    01187000 D
032D 5819 0000 0000 00F0      IF TRUE THEN SKIP                                             01188000 D
032E 30E0 0000 0000 0040      COMRPT - 1 = MPCR                                             01189000 D
032F 4809 2000 001C C0F0      LIT = MAR2              % RESTORE AMPCR FROM STACK            01190000 D
0330 02C0 0000 0000 00E0      STACK = LIT                                                   01191000 D
0331 2F30 C000 0000 0060      EINPUT - 1 = CPCR                                             01192000 D
0332 4809 0C40 0040 C0F0      B = AMPCR                                                     01193000 D
0333 4809 0000 0000 00FC      STEP                    % SEPARATE AMPCR ASSIGNMENTS AND JUMP 01194000 D
0334 482D 0000 0000 C0F0      JUMP                                                          01195000 D
                                                      %                                     01196000 D
                                                      %                                     01197000 D
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                                  EXPAND:                       * THIS ROUTINE WILL TAKE A BUFFER           01198000 D
                                                                * CONTAINING 32 BIT WORDS AND EXPAND EACH01199000 D
                                                                * INTO 2 - 32 BIT WORDS, PUTTING THE INFO01200000 D
                                                                * IN THE LHW OF EACH 32 BIT WORD.           01201000 D
                                                                * BR1 MUST CONTAIN THE BUFFER ADDRESS       01202000 D
                                                                * AND A3 MUST CONTAIN # OF BUFFERS/COUNT    01203000 D
0335  4809 0000 0030 20F0                 ASR                   * REFERENCE BR1                             01204000 D
0336  4809 CF40 A000 00F0                 DMAR R = A2                                                       01205000 D
0337  0000 0000 0030 0010                 8 = SAR                                                           01206000 D
0338  4809 E0C1 0030 C0F0                 A3 L = B              * ISOLATE THE COUNT(BUFF EXPAND FACTOR)     01207000 D
0339  0000 0000 0030 0020                 COMP 16 = SAR                                                     01208000 D
033A  4809 0C40 8B00 C0F0                 D R = B                                                           01209000 D
033B  4809 CC40 2000 00F0                 A2 + B= A2            * CALCULATE FIRST OUTPUT ADDRESS            01210000 D
033C  4809 C0DE 2000 00F0                 A2 - 1 = A2                                                       01211000 D
033D  4809 0641 002C 00F0                 AMPCR L = BR1         * RETURN IN BR1                             01212000 D
033E  0000 0000 0030 0030                 COMP 8 = SAR                                                      01213000 D
033F  4809 C001 0010 C0F0                 A2 L = BR2            * BUFFER ADDR + BEF - 1 IN BR2              01214000 D
0340  05D0 0003 0000 0060       FXPRPT:   EMULIN - 1 = CPCR     * CONTENTS OF 1 WORD INTO C                 01215000 D
0341  4809 0C41 2000 00F0                 B L = A2              * WORD CONTENTS INTO UHW OF A2              01216000 D
0342  0C00 0003 0000 C020                 COMP 16 = SAR                                                     01217000 D
0343  4809 C003 8030 24F0                 A2 R = MIR; ASE                                                   01218000 D
0344  4809 E001 2000 0CF0                 A3 L = A2             * ISOLATE BUFFER COUNT                      01219000 D
0345  4809 C000 A000 00F0                 A2 R = A2                                                         01220000 D
0346  4809 CF41 0010 00FC                 A2 + BMAR L = BR2     * BUFFER ADDR + COUNT INTO BR2              01221000 D
0347  0000 0000 0030 0030                 COMP 8 = SAR                                                      01222000 D
0348  05EC 0C00 0000 C060                 EMULOUT - 1 = CPCR    * OUTPUT 1 EXPANDED HALFWORD                01223000 D
0349  4809 0000 0000 24F0                 ASE                   * REFERENCE MAR2                            01224000 D
034A  4809 0F40 2030 0CF0                 BMAR = A2                                                         01225000 D
034B  4809 E0C1 0B00 C0F0                 A3 L = D              * ISOLATE THE COUNT                         01226000 D
034C  0000 0000 0C30 0020                 COMP 16 = SAR                                                     01227000 D
034D  4809 0C40 8B00 00FC                 B R = D               * COUNT INTO B                              01228000 D
034E  4809 CC5F 0010 00F0                 A2 - B L = BR2        * NEXT READ ADDRESS INTO BR2                01229000 D
034F  0000 0003 0000 0030                 COMP 8 = SAR                                                      01230000 D
0350  05F0 0000 0030 C060                 EMULIN - 1 = CPCR     * NEXT WORD INTO B                          01231000 D
0351  4809 0C40 8C30 00FC                 B R = MIR                                                         01232000 D
0352  0000 C0C0 0030 0020                 16 = SAR                                                          01233000 D
0353  4809 EC0F 2000 00F0                 A3 - 1 L = A2         * REDUCE THE COUNT BY 1                     01234000 D
0354  4809 C003 AC30 00F0                 A2 R = A2                                                         01235000 D
0355  4809 CF41 0010 C0F0                 A2 + BMAR L = BR2     * NEXT WRITE ADDRESS                        01236000 D
0356  0000 0003 0030 C030                 COMP 8 = SAR                                                      01237000 D
0357  060C 0060 0000 0060                 EMULOUT - 1 = CPCR    * WRITE OUT NEXT EXPANDED WORD              01238000 D
0358  4809 E0DE 1C0C C0F0                 A3 - 1 = A3           * REDUCE THE COUNT                          01239000 D
0359  4809 E0C1 2030 00F0                 A3 L = A2                                                         01240000 D
035A  000C 00C0 0030 C020                 COMP 16 = SAR                                                     01241000 D
035B  4809 C0C3 AB00 C0F0                 A2 R = A2, B                                                      01242000 D
035C  4809 C012 0000 00F0                 A2 ECL 0              * CHECK IF ALL WORDS EXPANDED               01243000 D
035D  5019 0003 0000 00F0                 IF FALSE THEN SKIP                                                01244000 D
035E  0610 C0C3 0030 C040                 EXPEND - 1 = MPCR                                                 01245000 D
035F  48C9 0F40 2000 00FC                 BMAR = A2                                                         01246000 D
0360  4809 CC53 0010 00F0                 A2 - B- 1 L = DR2     * NEXT READ ADDRESS                         01247000 D
0361  0000 0000 0C00 0030                 COMP 8 = SAR                                                      01248000 D
0362  33F0 00C3 0000 C040                 EXPRPT - 1 = MPCR                                                 01249000 D
0363  48C9 C0C0 0030 20F0       EXPEND:   ASR                   * REFERENCE MR1                             01250000 D
0364  48C9 0F40 8040 C0F0                 BMAR R = AMPCR        * RESTORE RETURN ADDRESS                    01251000 D
0365  000C C0C0 0030 0010                 8 = SAR                                                           01252000 D
0366  4809 C0C0 0030 C0F0                 STEP                                                              01253000 D
0367  482D C003 0000 00FC                 JUMP                                                              01254000 D
                                                                *                                           01255000 D
                                                                *                                           01256000 D
                                  EOUT:                         * THIS ROUTINE DUMPS THE BUFFERS            01257000 D
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                                                    * INDICATED BY THE BUFFER ADDRESS TO        01258000 D
                                                    * PRINTER, CRT, OR DISK (NOT IMPLEMENTED)01259000 D
0368 3809 0000 0000 00F0            IF LC2          * (IOCW) = A2; MAR2 = IOCW                 01260000 D
0369 4809 0000 0000 24F0            ASE             * REFERENCE OR2                            01261000 D
036A 4809 0F46 001C 00F0            BMAR + 1 = MAR2 * IOCW + 1                                 01262000 D
036B 2F30 00C0 0000 0060            EINPUT - 1 = CPCR * B = (IOCW+1)                           01263000 D
036C 4809 0C41 0020 00F0            B L = BR1       * STORE (IOCW + 1) BUFFER ADDRESS IN BR1  01264000 D
036D 0000 0000 0000 0030            COMP 8 = SAR                                               01265000 D
036E 4809 C0C0 A000 00F0            A2 R = A2                                                  01266000 D
036F A000 0000 0030 0010            14 = SAR        * A2 HAS DEVICE CODE                       01267000 D
0370 48C9 0640 0030 00F0            A2 + AMPCR = AMPCR                                         01268000 D
0371 062C 0000 0000 0000            OUTDEV - 1 = AMPCR                                         01269000 D
0372 4809 00C0 0000 C0F0            STEP                                                       01270000 D
0373 4824 0000 0000 00FC            EXEC                                                       01271000 D
                                                    *                                          01272000 D
0374 063C 0000 C000 0040   OUTDEV:  SPOO - 1 = MPCR                                            01273000 D
0375 0640 0000 0000 0040            PRTO - 1 = MPCR                                            01274000 D
0376 0650 0000 0000 0040            NOTIMP - 1 = MPCR * DISK IO NOT IMPLEMENTED                01275000 D
                                                    *                                          01276000 D
                           SPOO:                    * WRITE SPO FUNCTION                       01277000 D
0377 4849 0000 0000 00F0            SET LC2         * LC2 INDICATES IOCW + 1 WILL BE USED      01278000 D
0378 305C 0000 0000 0060            COMPRES - 1 = CPCR * COMPRESS BUFFER TO 32 BIT I/O FORMAT  01279000 D
0379 4809 2000 001C 00F0   BDSPO:   LIT + 1 = MAR2  * BUFFER ADDRESS TO MIR                    01280000 D
037A 032C 0000 0000 00E0            IOCW = LIT                                                 01281000 D
037B 2F30 0000 0000 0060            EINPUT - 1 = CPCR                                          01282000 D
037C 4809 0C40 0C30 CCF0            B = MIR                                                    01283000 D
037D 48C9 20C1 0F00 00F0            LIT L = BBI                                                01284000 D
037E 0070 C000 0000 C0A0            7 = LIT; COMP 16 = SAR                                     01285000 D
037F 4809 0C40 0090 24FC            B = MIR; ASE    * MIR CONTAINS 7/BUFFER ADDR.              01286000 D
0380 4809 0F45 0C1C 00F0            BMAR + 1 = MAR2 * BUFFER LENGTH INTO B (MAILBOX-1)         01287000 D
0381 2F3C C000 0C00 0060            EINPUT - 1 = CPCR                                          01288000 D
0382 48C9 CC40 2000 C0F0            B = A2          * TRANSFER BUFFER LENGTH INTO A2           01289000 D
0383 066C 0000 0000 C060            IOCIO - 1 = CPCR                                           01290000 D
0384 3780 0000 000C C040            BDSPO - 1 = MPCR                                           01291000 D
0385 4809 CC00 0090 C0F0            A2 = MIR        * SAVE A2 IN MIR                           01292000 D
0386 4809 E000 AC00 C0F0            A3 R = A2       * ISOLATE COUNTER                          01293000 D
0387 0000 0000 0000 0020            16 = SAR                                                   01294000 D
0388 4809 CCDE 2000 00F0            A2 - 1 = A2     * DECREMENT COUNTER                        01295000 D
0389 4809 EC01 9000 00F0            A3 C = A3       * DECREMENT COUNTER IN A3                  01296000 D
038A 4809 EDDE 1000 00F0            A3 - 1 = A3                                                01297000 D
038B 4809 EC01 9000 C0FC            A3 C = A3                                                  01298000 D
038C 4809 CC12 C000 C0F0            A2 EQL 0                                                   01299000 D
038D 6019 0C00 0000 00F0            IF FALSE THEN SKIP * TEST THE COUNTER FOR ZERO             01300000 D
038E 067C C000 0000 004C            OPCODE - 1 = MPCR                                          01301000 D
038F 48C9 2000 001C 00FC            LIT + 1 = MAR2  * REGENERATE BUFFER ADDRESS IN B           01302000 D
0390 032C 0000 C0C0 00E0            IOCW = LIT                                                 01303000 D
0391 2F3C 0C00 C000 0060            EINPUT - 1 = CPCR                                          01304000 D
0392 4809 0C40 2000 0CF0            B = A2, BMI     * B = BUFFER LENGTH, A2 = BUFFER ADDR      01305000 D
0393 4809 0C41 0B00 C0F0            B L = B         * MULTIPLY B BY 2                          01306000 D
0394 300C 0000 0000 0030            COMP 1 = SAR                                               01307000 D
0395 4809 CC41 0020 C0F0            A2 + B L = BR1  * NEW BUFFER ADDR IN BR1                   01308000 D
0396 0000 0C00 0000 0030            COMP 8 = SAR                                               01309000 D
0397 4809 CC40 0090 00F0            A2 + B = MIR    * NEW BUFFER ADDRESS IN IOCW +1            01310000 D
0398 2F5C C000 C000 006C            EOUTPUT - 1 = CPCR                                         01311000 D
0399 376C 0000 000C 0040            SPOO - 1 = MPCR                                            01312000 D
                                                    *                                          01313000 D
                           PRTO:                    * WRITE PRT FUNCTION                       01314000 D
039A 3C50 0000 0000 0060            COMPRES - 1 = CPCR * COMPRESS THE BUFFER                   01315000 D
039B 4809 2000 001C C0F0   BPRTO:   LIT + 1 = MAR2  * REGENERATE BUFFER ADDRESS                01316000 D
039C 032C 0000 0000 00E0            IOCW = LIT                                                 01317000 D
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039D  2F30 0000 0000 C060          EINPUT - 1 = CPCR                              01318000 D
039E  4809 0C40 0030 00F0          B = MIR                 * STORE BUFFER ADDRESS IN MIR   01319000 D
039F  4809 C0C1 0F30 C0F0          1 L = BB1                                      01320000 D
03A0  0C00 0000 000C 0020          COMP 16 = SAR                                  01321000 D
03A1  4809 0C40 0030 00F0          B = MIR                                        01322000 D
03A2  0680 0000 0000 0060          IOCIO - 1 = CPCR                               01323000 D
03A3  39AC 0000 0000 0040          PPRIO - 1 = MPCR                               01324000 D
03A4  4809 E000 A000 00FC          A3 R = A2               * ISOLATE COUNTER      01325000 D
03A5  000C C000 000C 002C          16 = SAR                                       01326000 D
03A6  4809 C0DE 2000 00F0          A2 - 1 = A2             * DECREMENT COUNTER    01327000 D
03A7  4809 EC01 9000 00F0          A3 C = A3               * DECREMENT COUNTER IN A3   01328000 D
03A8  4809 E0DE 1000 C0F0          A3 - 1 = A3                                    01329000 D
03A9  4009 E0C1 9000 C0F0          A3 C = A3               * RESTORE A3           01330000 D
03AA  4809 C012 0C30 C0FC          A2 EQL 0                * IS COUNTER = 0       01331000 D
03AB  6019 0000 0C30 00F0          IF FALSE THEN SKIP                             01332000 D
03AC  0690 0000 0000 0040          OPCODE - 1 = MPCR                              01333000 D
03AD  4809 20C0 001C 00F0          LIT + 1 = MAR2          * REGENERATE BUFFER ADDRESS   01334000 D
03AE  0320 0000 0000 00E0          IOCW = LIT                                     01335000 D
03AF  2F30 0000 0000 C060          EINPUT - 1 = CPCR                              01336000 D
03B0  4809 2C41 0020 00F0          LIT + B L = BR1         * WRITE NEW ADDRESS IN BR1   01337000 D
03B1  042C 0000 0000 00B0          66 = LIT; COMP 8 = SAR                         01338000 D
03B2  4809 2C40 0030 00F0          LIT + B = MIR           * WRITE NEW BUFFER ADDR IN IOCW +1   01339000 D
03B3  2F50 0000 C00C C060          EOUTPUT - 1 = CPCR                             01340000 D
03B4  3990 0000 0000 C040          PRIO - 1 = MPCR                                01341000 D
                                                           *                      01342000 D
                           IN:                             * THIS ROUTINE INPUTS DATA FROM   01343000 D
                                                           * PERIPHERAL DEVICES TO THE DESIGNATED   01344000 D
                                                           * BUFFERS. CRD READER, CRT, OR DISK (NI)   01345000 D
03B5  3809 C000 0030 C0F0          IF LC2                  * CLEAR LC2            01346000 D
03B6  4809 C000 A020 00F0          A2 R = A2               * A2 = (IOCW)          01347000 D
03B7  A000 0000 0000 0010          14 = SAR                * A2 CONTAINS DEVICE CODE   01348000 D
03B8  4809 C640 0C30 C0F0          A2 + AMPCR = AMPCR                             01349000 D
03B9  06A0 0000 0C30 00C0          INDEV - 1 = AMPCR                              01350000 D
03BA  4809 0000 0000 00F0          STEP                                           01351000 D
03BB  4824 0000 0C30 C0F0          EXEC                                           01352000 D
                                                           *                      01353000 D
03BC  06B0 0000 0030 0040  INDEV:  SPOI - 1 = MPCR                                01354000 D
03BD  06CC 0000 0000 0040          CRDI - 1 = MPCR                                01355000 D
03BE  06D0 0000 0000 0040          NOTIMP - 1 = MPCR       * DISK NOT IMPLEMENTED   01356000 D
                                                           *                      01357000 D
                           SPOI:                           * READ SPO FUNCTION    01358000 D
03BF  4809 20C0 C01C 00F0          LIT + 1 = MAR2          * RETRIEVE BUFFER ADDR.   01359000 D
03C0  032C 0000 0000 C0EC          IOCW = LIT                                     01360000 D
03C1  2F30 0000 0030 C060          EINPUT - 1 = CPCR                              01361000 D
03C2  4809 0C40 0030 00F0          B = MIR                 * STORE BUFFER ADDR IN MIR   01362000 D
03C3  4809 0C41 0020 00F0          B L = BR1               * STORE ADDRESS IN BR1   01363000 D
03C4  0000 0000 000C 0030          COMP 8 = SAR                                   01364000 D
03C5  4809 2001 CF00 00F0          LIT L = BB1                                    01365000 D
03C6  0060 0000 0030 C0AC          6 = LIT; COMP 16 = SAR                         01366000 D
03C7  4809 0C40 0030 00F0          B = MIR                                        01367000 D
03C8  06E0 0000 0000 0060          IOCIO - 1 = CPCR                               01368000 D
03C9  3BF0 0000 C00C C04C          SPOI - 1 = MPCR                                01369000 D
03CA  4809 E000 9000 00FC          A3 R = A3               * ISOLATE COUNTER      01370000 D
03CB  000C 0000 0C30 C020          16 = SAR                                       01371000 D
03CC  4809 E0DE 1C00 C0F0          A3 - 1 = A3             * DECREMENT COUNTER    01372000 D
03CD  4809 E0C1 1000 00F0          A3 L = A3               * RESTORE A3, LHW CLEARED   01373000 D
03CE  4809 E15C 100C 00F0          A3 OR LIT = A3          * BUFFER EXPANSION FACTOR IN LHW OF A3   01374000 D
03CF  014C 00C0 000C 00E0          20 = LIT                                       01375000 D
03D0  334C 0000 000C 0060          EXPAND - 1 = CPCR       * EXPAND BUFFER        01376000 D
03D1  4809 E000 A000 00FC          A3 R = A2               * ISOLATE COUNTER      01377000 D
```

```
03D3  4809 0C12 0000 00F0            A2 EQL 0               % IS COUNTER ZERO?
03D4  6019 0000 0000 C0F0            IF FALSE THEN SKIP
03D5  06F0 0000 0000 0040            OPCODE - 1 = MPCR
03D6  4809 20C0 001C C0F0            LIT + 1 = MAR2         % REGENERATE BUFFER ADDR
03D7  0320 0000 0000 00EC            IOCW = LIT
03D8  2F30 C000 0000 006C            EINPUT - 1 = CPCR
03D9  4809 2C40 003C 00F0            LIT + B = MIR
03DA  0280 C000 0000 00E0            40 = LIT               % NEXT BUFFER ADDR IN MIR (WITH BEF)
03DB  2F5C 0000 0000 0060            EOUTPUT - 1 = CPCR
03DC  3BE0 0000 0000 0040            SPOI - 1 = MPCR
                                                            %
                          CRDI:                             % READ CARD READER FUNCTION
03DD  4809 20C0 001C 00F0            LIT + 1 = MAR2         % RETRIEVE BUFFER ADDR.
03DE  0320 0000 0000 C0EC            IOCW = LIT
03DF  2F30 0000 0000 006C            EINPUT - 1 = CPCR
03E0  4809 0C40 0090 00F0            B = MIR                % STORE BUFFER ADDR IN MIR
03E1  4809 0C41 0020 00F0            B L = BR1              % STORE ADDRESS IN BR1
03E2  0000 0000 0000 C030            COMP 8 = SAR
03E3  0700 0000 0000 0060            IOCIO - 1 = CPCR
03E4  3DC0 0000 0000 C040            CRDI - 1 = MPCR
03E5  4809 E000 9000 CDF0            A3 R = A3              % ISOLATE COUNTER
03E6  0000 0000 0000 0020            16 = SAR
03E7  4809 EDDE 1000 00F0            A3 - 1 = A3            % DECREMENT COUNTER
03E8  4809 E001 1000 00F0            A3 L = A3              % RESTORE A3, LHW CLEARED
03E9  4809 E15C 1000 00F0            A3 OR LIT = A3         % BUFFER EXPANSION FACTOR IN LHW OF A3
03EA  014C 0000 0000 0DE0            20 = LIT
03EB  3340 0000 0000 C060            EXPAND - 1 = CPCR      % EXPAND BUFFER
03EC  4809 E000 A000 C0F0            A3 R = A2              % ISOLATE COUNTER
03ED  000C 0000 0000 C020            16 = SAR
03EE  4809 CC12 0000 C0F0            A2 EQL 0               % IS COUNTER ZERO?
03EF  6019 0000 0000 00F0            IF FALSE THEN SKIP
03F0  0710 C000 0000 0D40            OPCODE - 1 = MPCR
03F1  4809 20C0 001C 00FC            LIT + 1 = MAR2         % REGENERATE BUFFER ADDR
03F2  0320 0000 0000 00EC            IOCW = LIT
03F3  2F30 0000 0000 0060            EINPUT - 1 = CPCR
03F4  4809 2C40 003C 00F0            LIT + B = MIR
03F5  028C 0000 0000 C0EC            40 = LIT               % NEXT BUFFER ADDR IN MIR (WITH BEF)
03F6  2F5C 0000 0000 0060            EOUTPUT - 1 = CPCR
03F7  3DC0 0000 0000 0040            CRDI - 1 = MPCR
                                                            %
                                                            %
                          IOCIO:                            % THIS ROUTINE DOES EXTERNAL IO
                                                            % INTERFACE BETWEEN THE UYK20 IOC
                                                            % AND THE BURROUGHS IOP.  LC2 INDICATES
                                                            % IF MAILBOX -1 IS TO BE PASSED
03F8  1C88 0018 001C 00F0          . SET GC2; WHEN GC2 THEN B111=MAR2
03F9  98C9 C0D9 001C 1CFC            MW2; B110=MAR2; IF SAI
03FA  9C08 0C40 0090 00F0            WHEN SAI THEN D = MIR
03FB  3A0B 0018 001C 1CF0            B111 = MAR2; IF LC2 THEN MW2 ELSE SKIP
03FC  9B18 C000 0000 00F0            WHEN SAI THEN SET INT; SKIP
03FD  4909 0000 0000 00F0            SET INT
03FE  D008 0000 0000 C0F0            WHEN NOT INT THEN STEP
03FF  DE08 00C0 0000 CCF0            WHEN INT THEN DEX; MR2
0400  AEC8 0C42 0000 00F0            WHEN RDC THEN NOT B; RESET GC2
0401  682F 0000 000C C0F0            IF ABT THEN JUMP ELSE RETN
                                                            %
                                                            %
                          % * * * * * * * * * * * * INDIRECT WORD ROUTINES * * * * * * * * * * * * *
                                                            %
```

```
                                                          * IW1 AT Y = :Y: + (R(M))
                                                          * LC2 INDICATES BYTE INSTRUCTION
                                                          * ROUTINES RETURN B = Y
0402  4809 2000 001C 00F0            LIT = MAR2
0403  02C0 0000 C000 00E0            STACK = LIT             * STORE A3 WITH RETURN ADDR. IN STACK
0404  4809 E000 0030 00F0            A3 = MIR
0405  2F50 0000 0000 0060            EOUTPUT - 1 = CPCR      * WRITE TO EMULATION RESERVE BUFFER
0406  0720 0000 0000 0060            IFETCH - 1 = CPCR
0407  4809 E001 1000 00F0            A3 L = A3               * CLEAR UHW OF A3
0408  0000 0000 0000 0020            COMP 16 = SAR
0409  4809 E000 9000 00F0            A3 R = A3
040A  4809 0C41 0B00 00F0            B L = B                 * UHW OF A3 CONTAINS:Y:
040B  4809 EC5C 1000 00F0            A3 OR B = A3            * LHW OF A3 CONTAINS INSTRUCTION
040C  2380 0000 0000 0060            CONTENTSRM-1 = CPCR     * B = (R(M))
040D  4809 E000 AC00 00F0            A3 R = A2               * A2 CONTAINS :Y:
040E  0000 0000 0000 0020            16 = SAR
040F  4809 CC40 0B00 00F0            A2 + B = B              * CALCULATE ADDRESS OF Y
0410  0730 0000 0000 0040            INDIRWD - 1 = MPCR
                                                          *
                                                          *
                      IAWOI:                              * INDIRECT ADDRESSING WITHOUT INDEXING
                                                          * IW AT Y = :Y:
                                                          * LC2 INDICATES BYTE INST.; ROUTINE
                                                          * RETURNS B = Y AND A2 = (R(M))
0411  4809 2000 001C 00F0            LIT = MAR2
0412  02C0 0000 0030 00E0            STACK = LIT             * WRITE A3 WITH RETURN IN UHW
0413  4809 E000 0030 00F0            A3 = MIR
0414  2F50 0000 0000 0060            EOUTPUT - 1 = CPCR
0415  0740 0000 0000 0060            IFETCH - 1 = CPCR       * RETRIEVE :Y: FIELD
0416  0750 0000 0000 0040            INDIRWD - 1 = MPCR
                                                          *
                                                          *
                      INDIRWD:                            * THIS ROUTINE READS IN IW1 AND TESTS
                                                          * IF CASCADED OR DIRECT ADDRESSING IS
                                                          * REQUIRED
0417  4809 E001 1000 00F0            A3 L = A3               * CLEAR UHW OF A3
0418  0000 0000 0000 0020            COMP 16 = SAR
0419  4809 E000 9000 00F0            A3 R = A3
041A  4809 0C41 0010 00FC            B L = BR2
041B  0000 0000 0000 003C            COMP 8 = SAR            * BR2 = IW1 ADDRESS
041C  4809 0C41 0B00 00F0            B L = B
041D  0000 0000 0000 0020            COMP 16 = SAR           * SAVE IW1 ADDR IN UHW OF A3
041E  4809 EC5C 1000 00FC            A3 OR B = A3
041F  0760 0000 0000 0060            EMULIN - 1 = CPCR       * B = (IW1)
0420  4809 CC40 AC0C 00F0            B R = A2                * TEST IF BIT 14 OF IW1 IS SET
0421  A000 0000 0000 0010            14 = SAR
0422  4809 C000 C000 00F0            A2
0423  580B 0000 0000 C0F0            IF LST THEN STEP ELSE SKIP
0424  0770 0000 0000 C04C            CASCADED - 1 = MPCR     * IF BIT SET, CASCADED IW
0425  0780 0000 0000 0040            DIRECT - 1 = MPCR       * IF BIT NOT SET, FORM Y
                                                          *
                                                          *
                      CASCADED:                           * THIS ROUTINE DECIDES WHICH ADDRESSING
                                                          * FORMULA TO USE TO COMPUTE THE NEW
                                                          * LOCATION OF THE INDIRECT WORD
0426  4809 18C1 AC00 0CF0            B101 C = A2             * A2 IS BIT MASK FOR J FIELD OF IW
0427  3000 0000 0000 C020            19 = SAR
0428  4809 CC56 A000 00FC            A2 AND B R = A2
0429  300C 0000 0000 0010            12 = SAR
```

```
042A  4809 C640 0040 00F0           A2 + AMPCR = AMPCR     * COMPUTE FORMULA DESIRED                    01498000 D
042B  079C 0000 0000 C0C0           IWADOR - 1 = AMPCR                                                  01499000 D
042C  4809 0000 0030 00F0           STEP                                                                01500000 D
042D  4824 0000 0000 00F0           EXEC                                                                01501000 D
                                                           *                                            01502000 D
                                                           *                                            01503000 D
042E  07A0 0000 000C 0040  IWADDR:  ADTO - 1 = MPCR                                                     01504000 D
042F  07B0 0000 0030 0040           ADT1 - 1 = MPCR                                                     01505000 D
0430  07CC 000D 0000 0040           ADT2 - 1 = MPCR                                                     01506000 D
0431  07DC C000 0000 C040           ADT3 - 1 = MPCR                                                     01507000 D
                                                           *                                            01508000 D
                                                           *                                            01509000 D
                           ADTO:                           * NEW IW AT Y = IW2                          01510000 D
0432  4809 E000 A000 00F0           A3 R = A2              * SHIFT ADDR OF IW1 INTO A2                  01511000 D
0433  000C 0000 0030 0020           16 = SAR                                                            01512000 D
0434  4809 C00D 0010 C0F0           A2 OR 1 L = BR2        * NEXT ADDRESS OF IW                         01513000 D
0435  000C 0000 0030 003C           COMP 8 = SAR                                                        01514000 D
0436  07EC 0000 000C C060           EMULIN - 1 = CPCR      * B CONTAINS IW2; Y = IW2                    01515000 D
0437  416C 00C0 0000 0040           INDIRWD - 1 = MPCR     * Y = NEXT ADDR OF IW1                       01516000 D
                                                           *                                            01517000 D
                                                           *                                            01518000 D
                           ADT1:                           * NEW IW AT Y = IW2 + (R(X))                 01519000 D
0438  4809 2C56 0B30 C0F0           B AND LIT = B                                                       01520000 D
0439  00F0 00C0 000C 00EC           15 = LIT               * CREATE REGISTER R(X)                       01521000 D
043A  07F0 00C0 0030 0060           REGSTACK - 1 = CPCR                                                 01522000 D
043B  2F3C 000D 0030 0060           EINPUT - 1 = CPCR      * B = (R(X))                                 01523000 D
043C  0800 000D 0030 C040           ADYF - 1 = MPCR                                                     01524000 D
                                                           *                                            01525000 D
                                                           *                                            01526000 D
                           ADT2:                           * NEW INDIRECTWORD AT Y = IW2 + (R(M))       01527000 D
043D  2380 000D 0030 0C60           CONTENTSRM - 1 = CPCR  * A3 HAS INST. IN LOWER 16 BITS              01528000 D
                                                           * B = (R(M))                                 01529000 D
043E  0810 0C00 0000 0040           ADYF - 1 = MPCR                                                     01530000 D
                                                           *                                            01531000 D
                                                           *                                            01532000 D
                           ADT3:                           * NEW IW AT Y = IW2 + (R(M+1))               01533000 D
043F  4809 E156 0B3C 00F0           A3 AND LIT = B                                                      01534000 D
0440  00FC 0000 000C 00E0           15 = LIT                                                            01535000 D
0441  4809 0C46 0B30 C0F0           B + 1 = B              * B = RM+1                                   01536000 D
0442  0820 0000 C000 C060           REGSTACK - 1 = CPCR                                                 01537000 D
0443  2F3C 000D 003C C060           EINPUT - 1 = CPCR      * B = (R(M+1))                               01538000 D
0444  083C C00D 0030 C040           ADYF - 1 = MPCR                                                     01539000 D
                                                           *                                            01540000 D
                                                           *                                            01541000 D
                           ADYF:                           * THIS ROUTINE COMPUTES Y GIVEN              01542000 D
                                                           * B = (R(X)),(R(M)), OR (R(M+1))             01543000 D
0445  4809 E00D A00C 0CF0           A3 R = A2              * SHIFT ADDR OF IW INTO A2                   01544000 D
0446  000C 0000 0030 0020           16 = SAR                                                            01545000 D
0447  4809 C0DD 0C10 00F0           A2 OR 1 L = BR2        * NEXT ADDR OF IW                            01546000 D
0448  000C C0C0 0030 0030           COMP 8 = SAR                                                        01547000 D
0449  4809 0C40 200C 00FC           B = A2                 * SAVE (R(X)),(R(M)), OR (R(M+1)) IN A2      01548000 D
044A  084C C00D 003C 0060           EMULIN - 1 = CPCR      * B = (IW2)                                  01549000 D
044B  4809 CC40 0B3C 00F0           A2 + B = B             * Y = (IW2) + ((R(X)),(R(M)), OR (R(M+1))01550000 D
044C  416C 0C00 00C0 004C           INDIRWD - 1 = MPCR     * Y = NEXT ADDR OF IW1                       01551000 D
                                                           *                                            01552000 D
                                                           *                                            01553000 D
                           DIRECT:                         * THIS ROUTINE DECIDES WHAT ADDRESSING       01554000 D
                                                           * FORMULA TO COMPUTE Y - EFF. OPERAND        01555000 D
                                                           * ADDRESS                                    01556000 D
044D  4809 18C1 AC30 C0FC           B101 C = A2                                                         01557000 D
```

```
044E  3000 0000 0000 0020                 19 = SAR                  * MASK :J: FIELD OF IW1
044F  4809 CC56 A000 00F0                 A2 AND B R = A2
0450  3000 0000 0000 0010                 12 = SAR                  * ISOLATE BIT VALUE IN A2
0451  4809 C640 0030 C0F0                 A2 + AMPCR = AMPCR        * COMPUTE JUMP TABLE ADDRESS
0452  085C 0000 0000 0000                 DIRADDR - 1 = AMPCR       * FOR FORMULA DESIRED
0453  4809 0000 0000 00F0                 STEP
0454  4824 0000 0000 00F0                 EXEC
                                                                    *
                                                                    *
0455  0860 0000 0000 0040     DIRADDR:    DT0 - 1 = MPCR
0456  0870 0000 0000 0040                 DT1 - 1 = MPCR
0457  0880 0000 0000 0040                 DT2 - 1 = MPCR
0458  0890 0000 0000 0040                 DT3 - 1 = MPCR
                                                                    *
                                                                    *
                              DT0:                                  * Y = IW2
0459  4809 E000 A000 00FC                 A3 R = A2                 * SHIFT ADDR OF IW1 INTO A2
045A  0000 0000 0000 0020                 16 = SAR
045B  4809 CC00 0010 C0F0                 A2 OR 1 L = BR2
045C  0000 0000 0000 0030                 COMP 8 = SAR
045D  08A0 0000 0000 0060                 EMULIN - 1 = CPCR         * B = (IW2)
045E  3809 0000 0000 00F0                 IF LC2                    * CLEAR BYTE BIT(IF SET) LC2 = MS BYTE
045F  08B0 0000 0000 0040                 DTRETURN - 1 = MPCR
                                                                    *
                                                                    *
                              DT1:                                  * Y = IW2 + (R(X))
0460  4809 2C56 0B00 00FC                 B AND LIT = B
0461  00F0 0000 0000 00E0                 15 = LIT                  * ISOLATE RX FROM IW1
0462  08C0 C000 C000 C060                 REGSTACK - 1 = CPCR
0463  2F30 0000 0000 C060                 EINPUT - 1 = CPCR         * B = (R(X))
0464  08D0 0000 0000 0040                 DTGN - 1 = MPCR
                                                                    *
                                                                    *
                              DT2:                                  * Y = IW2 + (R(M))
0465  4809 E156 0B00 00F0                 A3 AND LIT = B
0466  00F0 0000 C000 00E0                 15 = LIT                  * MASK OFF :M: FIELD :M: = RM
0467  08E0 0000 0000 C060                 REGSTACK - 1 = CPCR
0468  2F30 C000 C000 006C                 EINPUT - 1 = CPCR         * B = (R(M))
0469  08F0 0000 0000 C040                 DTGN - 1 = MPCR
                                                                    *
                                                                    *
                              DT3:                                  * Y = IW2 + (R(M+1))
046A  4809 E156 0B00 00F0                 A3 AND LIT = B
046B  00F0 0000 0000 C0E0                 15 = LIT                  * MASK OFF RM INTO B
046C  4809 0C46 0B00 00FC                 B + 1 = B                 * B = RM + 1
046D  090C 0000 0000 0060                 REGSTACK - 1 = CPCR
046E  2F3C 0000 0000 0060                 EINPUT - 1 = CPCR         * P = (R(M+1))
046F  091C C000 0000 0040                 DTGN - 1 = MPCR
                                                                    *
                                                                    *
                              DTGN:                                 * THIS ROUTINE COMPUTES Y, TEST FOR BYTE
                                                                    * INST. AND RETURNS TO CALLER OF
                                                                    * RXMFIELD
0470  4809 E000 A000 C0F0                 A3 R = A2                 * IW1 ADDR INTO BR2 INC. BY 1
0471  0000 0000 C000 C020                 16 = SAR
0472  4809 C000 0010 C0FC                 A2 OR 1 L = BR2
0473  0000 0000 000C 003C                 COMP 8 = SAR
0474  4809 0C40 2000 00F0                 B = A2                    * SAVE (R(X)),(R(M)), OR(R(M+1)) IN A2
0475  0920 0000 0000 006C                 EMULIN - 1 = CPCR         * B = (IW2)
0476  4809 C000 0C9C 00F0                 A2 = MIR
```

```
0477  4809 0C40 2000 C0F0           B = A2,BMI                % A2 = IW2; B =(R(M)),(R(X)),(R(M+1))      01618000 D
0478  3A46 0000 0000 00FC           IF LC2 THEN SET LC2;STEP ELSE SKIP                                   01619000 D
0479  1E1C 00C0 0000 006C           BYTETEST - 1 = CPCR       % DO BYTE FUNCTION IF LC2 SET              01620000 D
047A  4809 CC40 CB0C 00F0           A2 + B = B                % B = Y                                    01621000 D
047B  093C 0000 0000 0040           DTRETURN - 1 = MPCR                                                  01622000 D
                                                              %                                          01623000 D
                                                              %                                          01624000 D
                        DTRETURN:                             % THIS ROUTINE RETURNS TO CALLER           01625000 D
                                                              % OF RXMFIELD; ENTERS WITH B = Y           01626000 D
047C  4809 0C40 2000 00F0           B = A2                    % A2 = Y                                   01627000 D
047D  4809 2000 0C1C C0F0           LIT = MAR2                                                           01628000 D
047E  02CC 0000 0000 00A0           STACK = LIT; 16 = SAR                                                01629000 D
047F  2F3C C0C0 0000 C060           EINPUT - 1 = CPCR         % READ IN CONTENTS OF  STACK               01630000 D
0480  4809 0C40 8040 00F0           B R = AMPCR               % RESTORE RETURN ADDRESS IN AMPCR          01631000 D
0481  4609 CC00 0800 00F0           A2 = B                    % B = Y                                    01632000 D
0482  482D 0000 0C00 00F0           JUMP                      % JUMP TO RXMFIELD CALLER                  01633000 D
                                                              %                                          01634000 D
                        % * * * * * * * * END INDIRECT WORD ROUTINES * * * * * * * * * * * * * * *01635000 D
                                                              %                                          01636000 D
                        LDBLE:                                % LOAD DOUBLE;                             01637000 D
                                                              % THIS ROUTINE TAKES AS INPUT AN ADDR.     01638000 D
                                                              % IN B AND STORES CONTENTS OF B AND B+1    01639000 D
                                                              % INTO RA,RA+1                             01640000 D
0483  4809 E001 100C 00F0           A3 L = A3                                                            01641000 D
0484  000C 0000 0000 0020           COMP 16 = SAR                                                        01642000 D
0485  4809 E65C 1000 C0F0           A3 OR AMPCR = A3          % SAVE RETURN IN UHW OF A3                 01643000 D
0486  4809 E001 9000 C0F0           A3 C = A3                                                            01644000 D
0487  4809 0C40 2000 C0F0           B = A2                    % SAVE Y OR Y* IN A2                       01645000 D
0488  4809 0C41 C010 C0F0           B L = BR2                                                            01646000 D
0489  000C 0000 C00C C030           COMP 8 = SAR                                                         01647000 D
048A  094C C0C0 0000 0060           EMULIN - 1 = CPCR         % (Y) OR (Y*) INTO B                       01648000 D
048B  4809 C000 001C C0FC           A2 OR 1 L = BR2           % BR2 HAS Y* +1 OR Y+1                     01649000 D
048C  0000 C000 0C00 0030           COMP 8 = SAR                                                         01650000 D
048D  4809 0C41 2000 C0F0           B L = A2                  % A2 = (Y*) UHW OR (Y) UHW                 01651000 D
048E  000C C0C0 000C 0620           COMP 16 = SAR                                                        01652000 D
048F  095C 0000 0C0C 0060           EMULIN - 1 = CPCR         % B = (Y*+1) OR (Y+1)                      01653000 D
0490  4809 CC5C 2000 00FC           A2 OR B = A2              % A2 = (Y*)/(Y*+1) OR (Y)/(Y+1)            01654000 D
0491  4809 E0C0 8D00 00FC           A3 R = B                  % MASK OFF :A: FIELD                       01655000 D
0492  90FC 0000 0C00 0080           4 = SAR; 15 = LIT                                                    01656000 D
0493  48C9 2C56 CBC0 00F0           LIT AND B = B             % :A: FIELD INTO B                         01657000 D
0494  4809 C000 803C C0F0           A2 R = MIR                % (Y) OR (Y*) INTO MIR                     01658000 D
0495  000C 00C0 C C0C 0020          16 = SAR                                                             01659000 D
0496  0960 00C0 0000 0060           REGSTACK - 1 = CPCR       % R(A) INTO MAR2                           01660000 D
0497  2F50 00C0 0000 C060           EOUTPUT - 1 = CPCR        % (Y) OR (Y*) INTO R(A)                    01661000 D
0498  4809 C0C0 0B0C C0F0           A2 = B                    % SET DOUBLEWORD ARITH COMPARE             01662000 D
0499  49C9 C0C0 C000 00F0           SET LC1                                                              01663000 D
049A  200C 0900 000C 006C           SETCCA - 1 = CPCR                                                    01664000 D
049B  4809 C0C1 200C 00F0           A2 L = A2                                                            01665000 D
049C  001C 0000 C000 00A0           COMP 16 = SAR;1 = LIT                                                01666000 D
049D  4809 2F5C 0C1C C0FC           LIT OR BMAR = MAR2        % R(A+1) INTO MAR2                         01667000 D
049E  48C9 C000 8030 00F0           A2 R = MIR                % (Y*+1) INTO MIR                          01668000 D
049F  2F5C 0000 C0CC 0060           EOUTPUT - 1 = CPCR                                                   01669000 D
04A0  4809 E0C0 8C40 00F0           A3 R = AMPCR              % RETURN ADDRESS IN AMPCR                  01670000 D
04A1  4809 0C00 0030 0GF0           STEP                                                                 01671000 D
04A2  482D 00C0 0030 00F0           JUMP                                                                 01672000 D
                                                              %                                          01673000 D
                                                              %                                          01674000 D
                        MOVE:                                 % MOVES THE NUMBER OF CELLS SPECIFIED      01675000 D
                                                              % BY UHW OF A3 FROM ADDR SPECIFIED BY BR101676000 D
                                                              % INTO ADDR  LOCATED IN LHW OF A3          01677000 D
```

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                                                     * PAGE ADDRESSING IS ALLOWED
04A3  4809 C640 2000 00F0           AMPCR = A2            * SAVE RETURN IN A2
04A4  4809 0000 0000 20F0  MRPT:    ASR
04A5  4809 0F40 0010 00F0           BMAR = BR2            * BR1 = BR2
04A6  0970 0000 0000 0060           EMULIN - 1 = CPCR     * B = (BR1)
04A7  4809 0C40 0C90 00F0           B = MIR               * TRANSFER B TO MIR
04A8  4809 C000 0B00 00F0           A2 = B                * STORE AMPCR IN B
04A9  4809 E001 0010 00F0           A3 L = BR2            * LHW OF A3 INTO BR2
04AA  0000 0000 000C 0030           COMP 8 = SAR
04AB  4809 E000 9000 00F0           A3 R = A3             * ZERO OUT LHW OF A3
04AC  0000 0000 0000 0020           16 = SAR
04AD  4809 E001 1000 00F0           A3 L = A3
04AE  4809 EC5C 1000 00F0           A3 OR B = A3          * STORE AMPCR IN LHW OF A3
04AF  0980 0000 0000 0060           EMULOUT - 1 = CPCR
04B0  4809 E001 2000 00F0           A3 L = A2             * STORE AMPCR IN UHW OF A2
04B1  0000 0000 0000 0020           COMP 16 = SAR
04B2  4809 C000 A000 00F0           A2 R = A2             * RETURN AMPCR TO LHW OF A2
04B3  4809 E000 9000 00F0           A3 R = A3             * ZERO LHW OF A3
04B4  4809 E001 1000 C0F0           A3 L = A3
04B5  4809 0F46 0B00 00F0           BMAR + 1 = B          * INCREMENT ADDRESS DESTINATION
04B6  4809 EC5C 1000 20F0           A3 OR B = A3; ASR     * STORE DESTINATION ADDR IN LHW OF A3
04B7  4809 0F40 8D00 40F0           BMAR R = B,CSAR
04B8  0000 0000 0000 0010           8 = SAR
04B9  4809 0C47 0020 00F0           B + 1 L = BR1         * INCREMENT ORIGIN
04BA  4809 E001 9000 00F0           A3 C = A3             * SHIFT COUNT TO LHW OF A3
04BB  0000 C000 0000 0020           16 = SAR
04BC  4809 E0DE 1800 00F0           A3 - 1 = A3,B         * DECREMENT COUNTER
04BD  4809 0C41 0B00 C0F0           B L = B               * ISOLATE COUNTER IN LHW OF B
04BE  4809 0C40 8B00 00F0           B R = B
04BF  4809 E001 9000 00F0           A3 C = A3             * RESTORE A3
04C0  4809 0C52 0000 00F0           B EOL 0
04C1  0000 0000 000C 0030           COMP 8 = SAR
04C2  6008 0000 0000 00F0           IF FALSE THEN STEP ELSE SKIP
04C3  4A3C 0000 0000 C040           MRPT - 1 = MPCR
04C4  4809 C000 0040 00F0           A2 = AMPCR
04C5  48C9 0000 0000 C0F0           STEP
04C6  482D 0000 0000 00F0           JUMP
                                                     *
                                                     *
                           MULT:                     * THIS ROUTINE WILL MULTIPLY 2 VALUES.
                                                     * THE OPERANDS MUST BE PASSED BY A2 AND B
                                                     * LC1 MUST BE SET IF 32 BIT NUMBERS ARE
                                                     * PASSED.  PRODUCT IS RETURNED IN A3.
04C7  4809 0000 1000 00F0           C = A3                * HOLDS PARTIAL PRODUCT
04C8  0000 0000 0000 0020           16 = SAR
04C9  28D9 0000 0000 00F0           IF LC1 THEN SET LC1; SKIP
04CA  0990 0000 0000 0040           SREG - 1 = MPCR       * DOUBLE PACK SINGLE REG VALUES
04CB  4809 0C52 0000 00F0  CMUL:    C EOL B
04CC  6400 CC4C 0000 0CF0           IF FALSE THEN A2 XOR B; STEP ELSE JUMP  * CHECK FOR NEG PROD
04CD  4A49 C000 000C C0F0           A2; IF MST THEN SET LC2 * FLAG FOR NEG PRODUCT
04CE  4CCB C002 2000 C0F0           IF MST THEN NOT A2 = A2; STEP ELSE SKIP
04CF  48C9 C0C0 2000 C0F0           A2 + 1 = A2           * TWO:S COMPLEMENT
04D0  4809 0C40 0000 00F0           B                     * BRING B TO THE ADDER
04D1  4C09 0C5E 0B00 00F0           IF MST THEN 0 - B = B  * COMPLEMENT B
04D2  2819 C000 0000 00F0           IF LC1 THEN SKIP
04D3  09AC 0000 0000 0040           RREG - 1 = MPCR       * RESTORE SINGLE REG TO LS WORDS
04D4  48C9 C000 0000 C0F0  MULT1:   A2                    * BRING A2 TO THE ADDER
04D5  5C09 EC40 1000 00F0           IF LST THEN A3 + B = A3
04D6  4809 C000 A000 40F0           A2 R = A2, CSAR       * SHIFT OFF LS BIT OF A2
04D7  1000 0000 0000 C000           1 = SAR
```

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04D8  4809 0C41 0B00 00F0            B L = B                % MULT MULTIPLIER BY 2                  01738000 0
04D9  4809 C000 0000 00F0            A2                     % CHECK TO SEE IF ENTIRE MULTIPLIER     01739000 0
04DA  4809 C012 0000 00F0            A2 EOL 0               % HAS BEEN REAL                         01740000 0
04DB  6819 0000 0000 00F0            IF TRUE THEN SKIP      % IF MULTIPLICAND = 0, THEN DONE        01741000 0
04DC  4D3C 0000 0000 0040            MULT1 - 1 = MPCR                                               01742000 0
04DD  3C00 E002 1C00 00F0            IF LC2 THEN NOT A3 = A3;STEP ELSE JUMP                         01743000 0
04DE  4809 E0C0 1000 00F0            A3 + 1 = A3                                                    01744000 0
04DF  4820 0000 0000 00F0            JUMP                                                           01745000 0
04E0  4809 0C41 0B00 C0F0   SREG:    B L = B                % MOVE B TO UHW                         01746000 0
04E1  4809 C0C1 2030 00F0            A2 L = A2              % MOVE A2 TO UHW, 16 = SAR              01747000 0
04E2  4CA0 0000 0000 C040            CMUL - 1 = MPCR        % CONTINUE MULT OP                      01748000 0
04E3  4809 C0C0 A00C 00F0   RREG:    A2 R = A2              % RESTORE REG TO LHW                    01749000 0
04E4  4809 0C40 8B00 C0F0            B R = B                % RESTORE REG TO LHW                    01750000 0
04E5  403C 0000 0000 C040            MULT1 - 1 = MPCR                                               01751000 0
                                                            %                                       01752000 0
                                                            %                                       01753000 0
                            NOTIMP:                         % THIS ROUTINE SETS UP AN ERROR MESSAGE 01754000 0
                                                            % "NOT IMPLEMENTED" INSERTED VIA LOADER  01755000 0
                                                            % JCL                                   01756000 0
04E6  09B0 0000 0000 0060            SAVEREG - 1 = CPCR                                             01757000 0
04E7  4809 0640 0B00 C0F0            AMPCR = B                                                      01758000 0
04E8  0CE0 0000 0000 00C0            ERRORLIST = AMPCR                                              01759000 0
04E9  4809 2C41 0020 00F0            LIT + 0 L = BR1        % CREATE ERRORLIST ADDR. IN BR1         01760000 0
04EA  0080 00C0 0C00 00B0            8 = LIT; COMP 8 = SAR                                          01761000 0
04EB  09C0 0000 0000 0040            PRTERR - 1 = MPCR                                              01762000 0
                                                            %                                       01763000 0
                                                            %                                       01764000 0
                            OVERFLOW:                       % THIS ROUTINE  WILL PRINT OUT AN ERROR 01765000 0
                                                            % DIAGNOSTIC INSERTED VIA LOADER JCL AND 01766000 0
                                                            % ABORTS MACHINE EXECUTION.             01767000 0
04EC  090C 0000 0000 0060            SAVEREG - 1 = CPCR                                             01768000 0
04ED  4809 0640 0B00 00F0            AMPCR = B              % TRANSFER ERRORLIST ADDR TO B          01769000 0
04EE  0CE0 0000 C000 00C0            ERRORLIST = AMPCR                                              01770000 0
04EF  4809 2C41 0C20 C0F0            LIT + B L = BR1        % CREATE ERRORLIST ADDR IN BR1          01771000 0
04F0  010C 0000 0000 C0B0            16 = LIT; COMP 8 = SAR                                         01772000 0
04F1  09E0 0C00 0000 0040            PRTERR - 1 = MPCR      % PRINT THE ERROR MESSAGE AND STOP      01773000 0
                                                            %                                       01774000 0
                            % * * * * * * * * * * * * *OVERFLOW BIT SETTING * * * * * * * * * * * * * 01775000 0
                                                            %                                       01776000 0
                            CHECKOV:                        % THIS ROUTINE WILL SET THE OVERFLOW BIT 01777000 0
                                                            % IF REQUIRED, OTHERWISE CLEAR IT       01778000 0
                                                            % A2 HOLDS "X", B HOLDS "Y", AND MIR    01779000 0
                                                            % HOLDS THE ALG SUM (IN MS WORDS)       01780000 0
                                                            % IF LC2 IS SET, IT IMPLIES A NEGATIVE  01781000 0
04F2  380B 00C0 0000 00FC            IF LC2 THEN STEP ELSE SKIP  % TEST FOR A SUBTRACTION OPCODE    01782000 0
04F3  4809 0C5E 0B00 00F0            C - B = E                                                      01783000 0
04F4  4809 C000 0000 C0F0            A2                     % A2 TO THE ADDER                       01784000 0
04F5  4BC9 0000 0000 00FC            IF MST THEN SET LC1    % IMPLIES X IS NEGATIVE                 01785000 0
04F6  4809 CC4C 0C00 00FC            A2 XOR B               % CHECK FOR "LIKE" SIGNS                01786000 0
04F7  480B 0C00 0C00 C0F0            IF MST THEN STEP ELSE SKIP                                     01787000 0
04F8  09FC 00C0 000C 0040            CLEAROV - 1 = MPCR     % CLEAR THE OV BIT, UNLIKE SIGNS        01788000 0
04F9  4809 00C0 0000 00F0            BMI                                                            01789000 0
04FA  4809 0C40 0070 00F0            B                                                              01790000 0
04FB  480B 00C0 0000 C0F0            IF MST THEN STEP ELSE SKIP  % CHECK FOR NEG SUM                01791000 0
04FC  0A0C C000 0000 004C            SNEG - 1 = MPCR        % NEG SUM, LIKE SIGNS                   01792000 0
04FD  280B C000 0000 00FC            IF LC1 THEN STEP ELSE SKIP                                     01793000 0
04FE  0A1C C000 0000 0040            SETOVBIT - 1 = MPCR    % POS SUM, LIKE SIGNS, NEG X            01794000 0
04FF  0A2C 00C0 0000 0040            CLEAROV - 1 = MPCR     % POS SUM, LIKE SIGNS, POS X            01795000 0
0500  280B 00C0 0C00 00FC   SNEG:    IF LC1 THEN STEP ELSE SKIP                                     01796000 0
0501  0A3C 00C0 0C00 0040            CLEAROV - 1 = MPCR     % NEG SUM, NEG X, LIKE SIGNS            01797000 0
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0502  0A40 0000 0000 0040            SETOVBIT - 1 = MPCR    * NEG SUM, LIKE SIGNS, POS X                01798000 D
                                                            *                                           01799000 D
                                                            *                                           01800000 D
0503  2808 0000 0000 00F0   OVOIT:   IF LC1 THEN STEP ELSE SKIP  * THIS ROUTINE WILL SET THE            01801000 D
0504  0A5C 0000 0000 0040            SETOVBIT - 1 = MPCR    * OVERFLOW BIT IN SR#1 IF LC1 IS SET        01802000 D
0505  0A6C 0000 0000 0040            CLEAROV - 1 = MPCR     * OTHERWISE, CLEAR THE OVERFLOW BIT         01803000 D
                                                            *                                           01804000 D
                                                            *                                           01805000 D
0506  4809 A001 C000 00F0   CLEAROV: A1 C = A1              * THIS ROUTINE WILL CLEAR THE OVERFLOW      01806000 D
0507  3000 0000 0000 0030            27 = SAR               * BIT IN SR#1                               01807000 D
0508  4809 A0CE 4000 40F0            A1 AND B110 = A1,CSAR                                              01808000 D
0509  2809 A001 C000 00F0            A1 C = A1; IF LC1      * CLEAR LC1 FROM CHECKOV                    01809000 D
050A  482D 0000 0000 00F0            JUMP                                                               01810000 D
                                                            *                                           01811000 D
                                                            *                                           01812000 D
                            SETOVBIT:                       * THIS ROUTINE SETS THE OVERFLOW BIT IN     01813000 D
                                                            * POSITION 27 OF PSW                        01814000 D
050B  4809 A001 C000 00F0            A1 C = A1                                                          01815000 D
050C  3000 0000 0000 C03C            27 = SAR                                                           01816000 D
050D  4809 A0D0 4000 40F0            A1 OR 1 = A1,CSAR                                                  01817000 D
050E  4809 A001 C000 00F0            A1 C = A1                                                          01818000 D
050F  482D 0000 0000 00F0            JUMP                                                               01819000 D
                                                            *                                           01820000 D
                            * * * * * * * * * * * * * * END OF OV BIT SETTING* * * * * * * * * * * * * *01821000 D
                                                            *                                           01822000 D
                            PRTERR:                         * THIS ROUTINE IS CALLED WHENEVER AN        01823000 D
                                                            * ERROR PRINTOUT IS GENERATED.              01824000 D
                                                            * B HAS THE ERRORLIST NUMBER.               01825000 D
0510  1F40 0000 0000 0060            CLEARBUFF - 1 = CPCR                                               01826000 D
0511  0A7C 0000 C000 0060            WRITEBUFF - 1 = CPCR   * WRITE A BLANK LINE                        01827000 D
0512  4809 0640 1000 00F0            AMPCR = A3             * WRITE PRINTBUFF ADDRESS INTO A3           01828000 D
0513  099C 0000 0000 00C0            PRINTBUFF = AMPCR                                                  01829000 D
0514  4809 2001 0800 00F0            LIT L = B              * LOAD COUNT IN UHW OF A3                   01830000 D
0515  0080 0000 0000 00A0            8 = LIT; COMP 16 = SAR * 8 WORDS WILL BE MOVED                     01831000 D
0516  4809 EC5C 1000 00FC            A3 OR B = A3                                                       01832000 D
0517  4A2C 0000 0000 0060            MOVE - 1 = CPCR        * MOVE ERROR DIAGNOSTIC INTO PRINTBUFF      01833000 D
0518  0A80 0000 0000 0060            WRITEBUFF - 1 = CPCR   * WRITE ERROR LIST MESSAGE                  01834000 D
0519  1F4C 0000 0000 0060            CLEARBUFF - 1 = CPCR                                               01835000 D
051A  0A90 0000 0000 0060            WRITEBUFF - 1 = CPCR                                               01836000 D
051B  0AAC C000 0000 0060            RESREG - 1 = CPCR      * RESTORE LU REGISTERS                      01837000 D
051C  0AB0 0000 0000 0040            STOPTIME - 1 = MPCR                                                01838000 D
                                                            *                                           01839000 D
                                                            *                                           01840000 D
                            REGSTACK:                       * THIS ROUTINE CHECKS THE STACK             01841000 D
                                                            * DESIGNATION BIT IN SR#1 TO DETERMINE      01842000 D
                                                            * WHICH STACK THE PROGRAMMER IS USING.      01843000 D
                                                            * THE B REGISTER IS ASSUMED TO HAVE THE     01844000 D
                                                            * RELATIVE REGISTER NUMBER.                 01845000 D
                                                            * WRAPAROUND IS ALLOWED.                    01846000 D
051D  4809 0C40 001C 00F0            B = MAR2               * STORE THE REGISTER                        01847000 D
051E  4809 A001 C000 C0F0            A1 C = A1              * POSITION STACK DESIGNATOR BIT IN LS BIT01848000 D
051F  0000 0000 0000 0020            16 = SAR               * POSITION REG BIT. IN LS BIT               01849000 D
0520  4809 A000 0000 00F0            A1                     * SEND A1 TO THE ADDER                      01850000 D
0521  580B 0000 0000 C0FC            IF LST THEN STEP ELSE SKIP                                         01851000 D
0522  0ACC 0000 0000 C040            STACK2 - 1 = MPCR                                                  01852000 D
0523  4809 2C52 0000 00FC            LIT EOL D                                                          01853000 D
0524  010C 0000 0000 00EC            16 = LIT                                                           01854000 D
0525  6806 0000 0000 00FC            IF TRUE THEN STEP ELSE SKIP                                        01855000 D
0526  4809 0000 001C C0FC            0 = MAR2                                                           01856000 D
0527  482D A001 C000 00F0            A1 C = A1; JUMP        * RESTORE A1 TO NORMAL SR#1/PAR FORMAT      01857000 D
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0528  4809 2C43 001C 00F0   STACK2:  LIT + B = MAR2                                                01858000 0
0529  0100 0000 0000 00E0            16 = LIT                                                      01859000 0
052A  4809 2C52 0000 00F0            LIT EQL B                                                     01860000 0
052B  0200 0000 0000 00E0            32 = LIT                                                      01861000 0
052C  6819 0000 0000 00F0            IF TRUE THEN SKIP                                             01862000 0
052D  4820 A0C1 C000 00F0            A1 C = A1 ; JUMP                                              01863000 0
052E  4809 2000 001C 00F0            LIT = MAR2                                                    01864000 0
052F  01C0 0000 0000 00E0            16 = LIT                                                      01865000 0
0530  482D A0C1 C000 00F0            A1 C = A1; JUMP                                               01866000 0
                                                            *                                      01867000 0
                                                            *                                      01868000 0
                            RESREG:                         * THIS ROUTINE RESTORES THE REGISTERS  01869000 0
                                                            * OF THE LU IN WORKSPACE               01870000 0
0531  4809 0640 0030 C0F0            AMPCR = MIR            * SAVE RETURN IN MIR                   01871000 0
0532  4809 2000 001C C0F0            LIT + 1 = MAR2         * MAR2 = WORKSPACE + 1                 01872000 0
0533  0260 0000 0000 00E0            WORKSPACE = LIT                                               01873000 0
0534  2F30 C000 0000 006C            EINPUT - 1 = CPCR                                             01874000 0
0535  4809 0C40 4000 00F0            B = A1                 * RESTORE A1                           01875000 0
0536  4809 0F46 001C C0F0            BMAR + 1 = MAR2        * INCREMENT WORKSPACE ADDR             01876000 0
0537  2F30 0000 0000 0060            EINPUT - 1 = CPCR                                             01877000 0
0538  4809 0C40 2000 C0F0            B = A2                 * RESTORE A2                           01878000 0
0539  4809 0F45 001C 00FC            BMAR + 1 = MAR2        * INCREMENT WORKSPACE ADDR             01879000 0
053A  2F30 0000 000C 0060            EINPUT - 1 = CPCR                                             01880000 0
053B  4809 0C40 1000 00F0            B = A3                 * RESTORE A3                           01881000 0
053C  4809 2000 001C 00F0            LIT = MAR2             * SELECT WORKSPACE BASE ADDR           01882000 0
053D  2F30 0000 0000 C060            EINPUT - 1 = CPCR                                             01883000 0
053E  4809 0C40 0030 C0F0            B = MIR,BMI            * SWAP B AND MIR                       01884000 0
053F  4809 0C40 0040 00F0            B = AMPCR,BMI          * RESTORE AMPCR AND B                  01885000 0
0540  4809 0000 0000 C0F0            STEP                                                          01886000 0
0541  482D 0000 0000 00F0            JUMP                                                          01887000 0
                                                            *                                      01888000 0
                                                            *                                      01889000 0
                            RESTPSW:                        * THIS ROUTINE WILL PLACE THE CONTENTS 01890000 0
                                                            * OF PSW INTO THE PAR, THEN RESTORE    01891000 0
                                                            * THE PAR TO (PAR) + 2.                01892000 0
0542  4809 0640 0030 0CF0            AMPCR = MIR            * SAVE RETURN ADDR TO OPCODE IN MIR    01893000 0
0543  4809 2000 001C C0F0            LIT = MAR2             * ADDRESS OF PSW                       01894000 0
0544  0200 0000 0000 00E0            PSW = LIT                                                     01895000 0
0545  2F3C 0000 0000 C060            EINPUT - 1 = CPCR      * (PSW) INTO B                         01896000 0
0546  4809 0C40 0030 C0F0            B = MIR,BMI            * (PSW) INTO MIR, RETURN ADDR INTO B   01897000 0
0547  4809 A001 2000 00F0            A1 L = A2              * PAR INTO A2                          01898000 0
0548  0020 0000 0000 00A0            COMP 16 = SAR; 2 = LIT                                        01899000 0
0549  4809 CC00 A000 00F0            A2 R = A2              * RIGHT JUSTIFY (PAR)                  01900000 0
054A  4809 C141 2000 C0F0            A2 + LIT L = A2        * (PAR) + 2 = A2                       01901000 0
054B  4809 CC5C 1000 00F0            A2 OR B = A3           * (PAR)+2/RETURN ADDR = A3             01902000 0
054C  4809 A000 C000 00F0            A1 R = A1              * CLEAR PAR                            01903000 0
054D  4809 A001 4000 00FC            A1 L = A1, BMI                                                01904000 0
054E  4809 AC5C 4000 00F0            A1 OR B = A1           * (PSW) INTO PAR                       01905000 0
054F  4809 B80E 4000 CCF0            A1 AND B011 = A1       * CLEAR BIASED FETCH BIT               01906000 0
0550  0A00 0000 0000 C060            IFETCH - 1 = CPCR      * INSTRUCTION AT Y INTO B              01907000 0
0551  4809 0C40 0030 00F0            B = MIR                                                       01908000 0
0552  4809 A000 C000 00F0            A1 R = A1              * CLEAR PAR                            01909000 0
0553  0000 0000 0000 0020            16 = SAR                                                      01910000 0
0554  4809 A001 4000 C0F0            A1 L = A1                                                     01911000 0
0555  4809 E000 8800 00F0            A3 R = B               * (PAR) + 2 = F                        01912000 0
0556  4809 AC5C 4000 00F0            A1 OR B = A1,BMI                                              01913000 0
0557  4809 E000 0040 C0F0            A3 = AMPCR             * RESTORE RETURN ADDR, INSTR IN B      01914000 0
0558  4809 0000 0000 00F0            STEP                                                          01915000 0
0559  483F 0000 0000 00F0            RETN                                                          01916000 0
                                                            *                                      01917000 0
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                                                          *
                        RI1:                              * THIS ROUTINE COMPUTES (P)+ D = P
                                                          * AND JUMPS TO NEXT INSTRUCTION
0550A 4809 0000 0B00 00F0          C = B
055B  4809 E001 1000 40F0          A3 L = A3, CSAR        * EXAMINE SIGN BIT OF "D"
055C  0000 0000 0000 C010          COMP 24 = SAR
055D  4809 E003 0030 C0F0          A3                     * A3 TO THE ADDER
055E  4C09 0019 CB00 00F0          IF MST THEN B111 L = B * IF SIGN=1, FILL UPPER BYTE WITH 1:S
055F  4809 E000 9000 C0F0          A3 R = A3              * RESTORE "D" FIELD TO LS BYTE
0560  4809 EC53 0B00 00F0          A3 OR B L = B          * B = SIGN/"D", IN MS WORD
0561  0000 0000 0000 C020          COMP 16 = SAR
0562  4809 A001 1000 C0F0          A1 L = A3              * SAVE THE OLD PAR IN MS WORD OF A3
0563  4809 EC40 8B00 C0F0          A3 + B R = B           * ALGEBRAICALLY ADD (P) + D
0564  4809 A003 C000 00F0          A1 R = A1              * CLEAR OLD PAR
0565  4809 A001 4000 00FC          A1 L = A1
0566  4809 AC5C 4000 00F0          A1 OR B = A1           * CREATE NEW PAR
0567  0AEC 0000 0000 0040          OPCODE - 1 = MPCR
                                                          *
                                                          *
                        RM:                               * THIS ROUTINE GETS THE CONTENTS OF R(M)
                                                          * :M: INDICATED IN MAR AND RETURNS
                                                          * IT IN MIR
0568  4809 0000 0000 24F0          ASE                    * REFERENCE MAR2
0569  4809 0640 2000 00F0          AMPCR = A2             * SAVE RETURN ADDRESS
056A  4809 0F40 0B00 00F0          BMAR = B
056B  51C0 0000 0000 0060          REGSTACK - 1 = CPCR    * SELECT REGISTER STACK TO BE USED
                                                          * ADDR OF GEN REG STACK RETURNED IN MAR2
056C  2F30 0000 0000 0060          EINPUT - 1 = CPCR      * GET CONTENTS OF R(M)
056D  4809 C000 0040 C0F0          A2 = AMPCR             * RESTORE RETURN ADDRESS
056E  4809 0C40 0C30 00F0          B = MIR                * MIR IS USED AS TEMP STORAGE
056F  4800 0000 0000 00F0          WAIT                   * FOR TEST PURPOSES
0570  4820 0000 0000 00F0          JUMP
                                                          *
                                                          *
                        * * * * * * * * * * * * * RX FORMAT ROUTINES * * * * * * * * * * * * * *
                                                          *
                                                          *
                        RXMFIELD:                         * THIS ROUTINE ANALYZES THE "M" FIELD OF
                                                          * A TYPE RX INSTRUCTION.  UPON ENTRANCE
                                                          * A3 CONTAINS THE MOST SIGNIF. WORD OF
                                                          * THE DOUBLEWORD INSTRUCTION.  LC2
                                                          * INDICATES BYTE INSTRUCTION.  UPON EXIT
                                                          * OF DAWI, DAWOI, OR INDIRECTION
                                                          * B CONTAINS Y: LC2 PASSES MS(0),LS(1)
0571  4809 E001 9000 00F0          A3 C = A3              * PREPARE MS 2 BYTES OF A3 TO HOLD RETURN
0572  000C 0000 0000 0020          16 = SAR               * ADDRESS
0573  4809 E65C 1000 00F0          A3 OR AMPCR = A3       * PUT RETURN ADDR IN A3(UPPER HALF)
0574  4809 E001 9000 00FC          A3 C = A3              * RESTORE A3 RETURN ADDR/INSTRUCTION
0575  4809 E156 0B00 00F0          A3 AND LIT = B         * MASK OFF "M" FIELD
0576  0CF0 0003 0000 00E0          15 = LIT
0577  4809 0C52 0000 C0F0          B EQL 0                * IS M = 0?
0578  680B 0000 0000 C0F0          IF TRUE THEN STEP ELSE SKIP
0579  0AFC 0000 0000 0040          DAWOI - 1 = MPCR       * JUMP TO DIRECT ADDRESS W/O INDEXING
057A  4809 2C5B 0000 0CF0          B GEQ LIT              * TEST FOR M = 1XXX
057B  0080 0000 0000 C0E0          8 = LIT
057C  780B 0000 0000 00F0          IF FALSE THEN STEP ELSE SKIP
057D  0B00 0000 0000 0040          DAWI - 1 = MPCR        * JUMP TO DIRECT ADDR WITH INDEXING
057E  4809 0C40 2000 C0F0          B = A2                 * SAVE B IN A2
057F  500B 0000 0000 00F0          IF NOT LST THEN STEP ELSE SKIP
0580  0B1C 0000 0000 C040          INDIR - 1 = MPCR       * IF M = 10,12,14,16 THEN INDIRECTION
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0581 0820 0000 0000 0040          DAWI - 1 = MPCR        * OTHERWISE, M = 11,13,15,17 PERFORM    01978000 D
                                                         * DIRECT ADDRESSING WITH INDEXING (R(M)) 01979000 D
                                                         *                                       01980000 D
                                                         *                                       01981000 D
                         DAWOI:                          * THIS ROUTINE RETURNS Y IN D           01982000 D
                                                         * AND JUMPS TO CALLING ROUTINE          01983000 D
                                                         * OF RXMFIELD                           01984000 D
0582 0030 0000 0000 0060          IFETCH - 1 = CPCR      * B HAS Y                               01985000 D
0583 4809 E000 8030 00F0          A3 R = AMPCR           * RESTORE RETURN ADDR FROM RXMFIELD     01986000 D
0584 0000 0000 0030 C020          16 = SAR                                                       01987000 D
0585 3809 0000 0000 00F0          IF LC2                 * CLEAR BYTE BIT, LC2=0; MSBYTE OF Y    01988000 D
0586 4820 0000 0000 00F0          JUMP                   * RETURN TO CALLING ROUTINE OF RXMFIELD 01989000 D
                                                         *                                       01990000 D
                                                         *                                       01991000 D
                         DAWI:                           * THIS ROUTINE FORMS Y = Y + (R(M))     01992000 D
                                                         * RETURNS Y IN B                        01993000 D
0587 0840 0000 0030 0060          IFETCH - 1 = CPCR      * GET NEXT ADDRESS                      01994000 D
0588 4009 0C40 2030 00F0          B = A2                 * A2 HAS "Y"                            01995000 D
0589 4809 E155 0800 00FC          A3 AND LIT = B         * RETRIEVE RELATIVE  REG. NO.           01996000 D
058A 00FC 0000 0000 00E0          15 = LIT               * MASK                                  01997000 D
058B 51C0 0000 0000 0060          REGSTACK - 1 = CPCR    * SELECT REG. STACK TO BE USED          01998000 D
                                                         * COMPUTED ACTUAL LOCATION IN MAR2      01999000 D
058C 2F3C 0000 0030 C060          EINPUT - 1 = CPCR      * B HAS (R(M))                          02000000 D
058D 3A9B 0000 0000 C0F0          IF LC2 THEN SET LC2; STEP ELSE SKIP                            02001000 D
058E 1E1C 0000 0030 0060          BYTETEST - 1 = CPCR    * CHECK FOR BYTE INSTRUCTION            02002000 D
058F 4809 CC40 0800 00F0          A2 + B = B             * B HAS Y                               02003000 D
0590 4809 E000 8090 00F0          A3 R = AMPCR           * RESTORE RETURN ADDR FROM RXMFIELD     02004000 D
0591 0000 0000 0030 002C          16 = SAR                                                       02005000 D
0592 4009 0000 0000 00F0          STEP                                                           02006000 D
0593 4820 0000 0030 00F0          JUMP                   * RETURN TO CALLING ROUTINE OF RXMFIELD 02007000 D
                                                         *                                       02008000 D
                                                         *                                       02009000 D
                         INDIR:                          * THIS ROUTINE IS CALLED IF M=10,12,14,1602010000 D
0594 4809 2000 C01C C0F0          LIT = MAR2             * LOAD ADDR OF SR#2 REGISTER INTO MAR2  02011000 D
0595 0220 0000 0030 00E0          STATUS2 = LIT                                                  02012000 D
0596 2F30 0000 0000 0060          EINPUT - 1 = CPCR      * READ SR#2 INTO B TO USE SRM ROUTINES  02013000 D
0597 4809 C152 0030 00F0          A2 EOL LIT                                                     02014000 D
0598 0080 0000 0000 00E0          8 = LIT                                                        02015000 D
0599 6419 C152 0030 C0F0          IF FALSE THEN A2 EOL LIT; SKIP  * TEST IF M = 10               02016000 D
059A 0B50 0000 0030 0040          SRM10 - 1 = MPCR       * JUMP TO SR#2 "M" FIELD ROTUINE        02017000 D
059B 00AC 0000 0030 00E0          10 = LIT                                                       02018000 D
059C 6419 C152 0000 C0F0          IF FALSE THEN A2 EOL LIT; SKIP  * TEST IF M = 12               02019000 D
059D 0B60 0000 000C 0040          SRM12 - 1 = MPCR                                               02020000 D
059E 00CC 0000 0030 00E0          12 = LIT                                                       02021000 D
059F 6019 C000 003C 00FC          IF FALSE THEN SKIP     * TEST IF M = 14                        02022000 D
05A0 0B7C 0000 0000 0040          SRM14 - 1 = MPCR                                               02023000 D
05A1 0B80 0000 0000 C04C          SRM16 - 1 = MPCR       * DEFAULTS TO M = 16                    02024000 D
                                                         *                                       02025000 D
                                                         *                                       02026000 D
                         SRM10:                          * THIS ROUTINE WILL REMOVE THE "M" FIELD 02027000 D
                                                         * FROM SR#2 AND CALL THE APPROPRIATE    02028000 D
                                                         * INDIRECT ADDRESSING ROUTINE           02029000 D
05A2 4809 18C1 AC30 00F0          B101 C = A2            * ISOLATE :M: FIELD = 10                02030000 D
05A3 3000 0000 0030 0020          23 = SAR                                                       02031000 D
05A4 4809 CC56 8B30 C0F0          A2 AND B R = B         * B CONTAINS STATUS REG 2               02032000 D
05A5 0000 0000 0000 0010          8 = SAR                                                        02033000 D
05A6 0B90 0000 0030 C040          SRMTEST - 1 = MPCR     * JUMP TO TEST CONTENTS ROUTINE         02034000 D
                                                         *                                       02035000 D
                                                         *                                       02036000 D
                         SRM12:                          * THIS ROUTINE WILL REMOVE THE :M: FIELD 02037000 D
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                                                          * INDIRECT ADDRESSING ROUTINE              02038000 0
                                                          * FROM SR#2 AND CALL THE APPROPRIATE       02039000 0
05A7  4809 18C1 A000 00F0          0101 C = A2            * ISOLATE :M: FIELD = 12                   02040000 0
05A8  9000 0000 0030 0020          21 = SAR                                                          02041000 0
05A9  4809 CC56 8B0C 00F0          A2 AND D R = B         * B CONTAINS STATUS REG 2                  02042000 0
05AA  2000 0000 0000 0010          10= SAR                * B CONTAINS CONTENTS OF :M: FIELD         02043000 0
05AB  0BA0 0000 0030 0040          S3MTEST - 1 = MPCR     * JUMP TO TEST CONTENTS ROUTINE            02044000 0
                                                          *                                          02045000 0
                                                          *                                          02046000 0
                        SRM14:                            * THIS ROUTINE WILL REMOVE THE :M: FIELD   02047000 0
                                                          * FROM SR#2 AND CALL THE APPROPRIATE       02048000 0
                                                          * INDIRECT ADDRESSING ROUTINE              02049000 0
05AC  4809 18C1 A030 00F0          0101 C = A2            * ISOLATE :M: FIELD = 14                   02050000 0
05AD  3000 0003 0030 0020          19 = SAR                                                          02051000 0
05AE  4809 CC56 8B00 00F0          A2 AND B R = B         * B CONTAINS STATUS REG 2                  02052000 0
05AF  8000 0000 0030 0010          12= SAR                * B CONTAINS CONTENTS OF :M: FIELD         02053000 0
05B0  0BB0 0000 0030 0040          S3MTEST - 1 = MPCR     * JUMP TO TEST CONTENTS ROUTINE            02054000 0
                                                          *                                          02055000 0
                                                          *                                          02056000 0
                        SRM16:                            * THIS ROUTINE WILL REMOVE THE :M: FIELD   02057000 0
                                                          * FROM SR#2 AND CALL THE APPROPRIATE       02058000 0
                                                          * INDIRECT ADDRESSING ROUTINE              02059000 0
05B1  4809 18C1 A030 00F0          0101 C = A2            * ISOLATE :M: FIELD = 16                   02060000 0
05B2  1000 0000 0030 0020          17 = SAR                                                          02061000 0
05B3  4809 CC56 8B30 00F0          A2 AND B R = B         * B CONTAINS STATUS REG 2                  02062000 0
05B4  A000 0000 0000 0010          14= SAR                * B CONTAINS CONTENTS OF :M: FIELD         02063000 0
05B5  0BC0 0000 0030 0040          S3MTEST - 1 = MPCR     * JUMP TO TEST CONTENTS ROUTINE            02064000 0
                                                          *                                          02065000 0
                                                          *                                          02066000 0
                        SRMTEST:                          *  THIS ROUTINE ANALYSES THE :M: FIELD     02067000 0
                                                          * CONTENTS M = 0,1,2,3                     02068000 0
05B6  4809 2C5E 0030 00F0          LIT GEQ B                                                         02069000 0
05B7  0010 0000 0000 00E0          1 = LIT                                                           02070000 0
05B8  7419 2C52 0000 00F0          IF FALSE THEN LIT EQL B; SKIP  * TEST CONTENTS OF "M"(0 OR 1)     02071000 0
05B9  586C 0003 0000 0040          DAWI - 1 = MPCR        * DIRECT ADDRESSING WITH INDEXING          02072000 0
05BA  0020 0000 0000 00E0          2 = LIT                                                           02073000 0
05BB  6819 0000 0030 00F0          IF TRUE THEN SKIP      * TEST IF "M" = 2                          02074000 0
05BC  401C 0000 0030 0040          IAWI - 1 = MPCR        * JUMP TO INDIRECT ADDR WITH INDEXING      02075000 0
05BD  4100 0000 0030 0040          IAWOI - 1 = MPCR       * INDIRECT ADDR WITHOUT INDEXING           02076000 0
                                                          *                                          02077000 0
                        * * * * * * * * * * END RX FORMAT ROUTINES * * * * * * * * * * * * * * * * *02078000 0
                                                          *                                          02079000 0
                        SAVEREG:                          * THIS ROUTINE SAVES LU(LOGIC UNIT) REG.   02080000 0
05BE  4809 0003 0000 24F0          ASE                    * REFERENCE BR2/MAR                        02081000 0
05BF  4809 0C40 0030 00F0          B = MIR                * STORE B IN MIR                           02082000 0
05C0  4809 0640 0B00 00F0          AMPCR = B              * SAVE RETURN IN B                         02083000 0
05C1  4809 2003 001C 00F0          LIT = MAR2                                                        02084000 0
05C2  0260 0000 0030 00E0          WORKSPACE = LIT        * WRITE B INTO WORKSPACE                   02085000 0
05C3  2F50 0003 0000 0060          FOUTPUT - 1 = CPCR                                                02086000 0
05C4  4809 0F46 001C 00F0          BMAR + 1 = MAR2                                                   02087000 0
05C5  4809 A000 0030 00F0          A1 = MIR               * WRITE A1 INTO WORKSPACE +1               02088000 0
05C6  2F50 0000 0000 0060          EOUTPUT - 1 = CPCR                                                02089000 0
05C7  4809 0F46 001C 00F0          BMAR + 1 = MAR2                                                   02090000 0
05C8  4809 C000 0030 00F0          A2 = MIR               * WRITE A2 INTO WORKSPACE + 2              02091000 0
05C9  2F50 0003 0000 0060          EOUTPUT - 1 = CPCR                                                02092000 0
05CA  4809 0F46 001C 00F0          BMAR + 1 = MAR2                                                   02093000 0
05CB  4809 E000 0030 00F0          A3 = MIR               * WRITE A3 INTO WORKSPACE + 3              02094000 0
05CC  2F50 0003 0000 0060          EOUTPUT - 1 = CPCR                                                02095000 0
05CD  4809 0C40 009C 00F0          B = AMPCR              * RESTORE ADDRESS                          02096000 0
05CE  4809 0003 0030 00F0          STEP                                                              02097000 0
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05CF   4820 C000 000C C0F0          JUMP                                                   02098000 0
                                                                   *                       02099000 0
                                                                   *                       02100000 0
                     STARTTIME:                                    * THIS ROUTINE STARTS THE EXTERNAL       02101000 0
                                                                   * CLOCK OF THE IOP.     02102000 0
05D0   4809 2001 0B00 00F0          LIT L = B                                              02103000 0
05D1   0020 0000 0000 C0A0          2 = LIT; COMP 16 = SAR         * PUT FUNCTION 2 INTO B  02104000 0
05D2   4809 2050 0030 00FC          LIT OR B = MIR                 * PUT START CLOCK FUNCTION INTO MIR      02105000 0
05D3   0010 0000 0000 00E0          1 = LIT                                                02106000 0
05D4   2F70 0000 0000 0060          EXTIO - 1 = CPCR               * CALL IOP              02107000 0
05D5   4809 0000 0000 00FC          STEP                                                   02108000 0
05D6   0B00 0000 0000 004D          OPCODE - 1 = MPCR              * START EXECUTION       02109000 0
                                                                   *                       02110000 0
                                                                   *                       02111000 0
                     STOPTIME:                                     * THIS ROUTINE SAMPLES THE EXTERNAL      02112000 0
                                                                   * CLOCK OF THE IOP AND INSERTS THE TIME  02113000 0
                                                                   * INTO CLOCKTIME IN S-MEMORY AND CALLS   02114000 0
                                                                   * THE LOADER.           02115000 0
05D7   4809 2001 0030 00F0          LIT L = MIR                    * STORE FUNCTION IN MIR  02116000 0
05D8   0020 0000 0000 C0A0          2 = LIT; COMP 16 = SAR         * PUT FUNCTION 2 IN B    02117000 0
05D9   2F70 0000 0000 0060          EXTIO - 1 = CPCR               * CALL IOP              02118000 0
05DA   5060 0000 0000 004C          STOPTIME - 1 = MPCR            * REREAD TIME           02119000 0
05DB   4809 0C40 0030 00FC          B = MIR                        * PUT CONTENTS OF MAILBOX INTO MIR       02120000 0
05DC   4809 2000 001C 00F0          LIT = MAR2                                             02121000 0
05DD   024C 0000 0000 00E0          CLOCKTIME = LIT                * CLOCKTIME ADDRESS IN MAR2              02122000 0
05DE   2F50 0000 0000 006D          EOUTPUT - 1 = CPCR             * WRITE CLOCK INTO CLOCKTIME             02123000 0
05DF   4809 2000 001C 00F0          LIT = MAR2                                             02124000 0
05E0   0220 0000 0000 00EC          STATUS2 = LIT                                          02125000 0
05E1   2F30 0000 0000 0060          EINPUT - 1 = CPCR              * READ IN SR #2         02126000 0
05E2   4809 0C40 0000 00FC          B                              * SR # 2 TO THE ADDER   02127000 0
05E3   4806 0000 0000 00F0          IF MST THEN STEP ELSE SKIP  * TRACE IF TRUE           02128000 0
05E4   27E0 0000 000C 0060          DUMPREG - 1 = CPCR             * DUMP AN/UYK20 REGISTERS, ETC           02129000 0
05E5   0600 0000 0000 0040          NEWCARD - 1 = MPCR             * RETURN TO LOADER FOR ADDITIONAL INPUT  02130000 0
                                                                   *                       02131000 0
                                                                   *                       02132000 0
                     WRITEBUFF:                                    * THIS ROUTINE WILL PRINTOUT THE CONTENTS02133000 0
                                                                   * OF PRINTBUFF TO THE CRT OR PTR         02134000 0
                                                                   * A2, MIR, AND B ARE USED IN THIS ROUTINE02135000 0
05E6   4809 D640 2000 00F0          AMPCR = A2                     * SAVE AMPCR            02136000 0
05E7   4809 2000 0030 C0F0  BOOUT:  LIT = MIR                      * PUT ADDRESS OF PRINTBUFF IN MIR        02137000 0
05E8   0990 0000 0000 00E0          PRINTBUFF = LIT                                        02138000 0
05E9   4809 2000 001C C0FC          LIT = MAR2                     * ADDR OF SR#2 INTO MAR2 02139000 0
05EA   B220 0000 0000 00B0          STATUS2 = LIT; COMP 1 = SAR                            02140000 0
05EB   2F30 0000 0000 0060          EINPUT - 1 = CPCR              * SR#2 INTO B           02141000 0
05EC   4809 0C41 0B00 00FC          B L = B                        * EXAMINE 2ND MS BIT OF SR#2             02142000 0
05ED   4809 0000 0000 00FD          STEP                                                   02143000 0
05EE   007C 0000 0000 00AC          COMP 16 = SAR; 7 = LIT                                 02144000 0
05EF   4809 0C40 0000 00F0          B                              * BRING B TO THE ADDER  02145000 0
05F0   4C19 2001 0FD0 00F0          IF MST THEN LIT L = BBI; SKIP  * CRT FUNCTION          02146000 0
05F1   4809 00C1 0F00 C0FC          1 L = BBI                      * PRINTER FUNCTION      02147000 0
05F2   4809 0C40 0030 00FC          B = MIR                        * MIR CONTAINS 1/PRINTBUFF OR 7/PRINTBUFF02148000 0
05F3   4809 2000 0B00 00F0          LIT = B                        * 33 INTO B             02149000 0
05F4   021C 0000 0000 00E0          33 = LIT                                               02150000 0
05F5   2F70 0000 0000 0060          EXTIO - 1 = CPCR               * WRITE TO CRT/PTR 33 WORDS IN PBUFF     02151000 0
05F6   5E60 0000 000C 004C          BOOUT - 1 = MPCR               * REPEAT EXTIO, I/O NOT COMPLETE         02152000 0
05F7   4809 C000 0040 C0FD          A2 = AMPCR                     * RESTORE AMPCR         02153000 0
05F8   4809 0000 0000 00FD          STEP                           * REQUIRED BETWEEN 2 TYPE II INSTRUCTIONS02154000 0
05F9   4820 0000 0000 00F0          JUMP                                                   02155000 0
                                                                   *                       02156000 0
                                                                   *                       02157000 0
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                                       XFCODE:                          * THIS ROUTINE WILL EXAMINE THE "F" CODE 02158000 D
05FA  4809 E000 A000 00F0                        A3 R = A2              * OF AN INSTRUCTION IN B AND RETURN THE  02159000 D
05FB  0000 0000 0000 C010                        B = SAR                * "F" CODE IN LS 2 BITS OF A2            02160000 D
05FC  4809 C155 2000 00F0                        A2 AND LIT = A2                                                 02161000 D
05FD  0030 C000 0000 00EC                        3 = LIT                                                         02162000 D
05FE  482D 0000 0000 00F0                        JUMP                                                            02163000 D
                                                                        *                                        02164000 D
                                       * * * * * * * * * * * * * * FETCH ROUTINES * * * * * * * * * * * * * * * *02165000 D
                                                                        *                                        02166000 D
                                       BKTCMP:                          * BKPT STATUS BIT HAS BEEN SET IN SR#1   02167000 D
                                                                        * BR1 CONTAINS THE ADDRESS TO BE MATCHED.02168000 D
                                                                        * BR2 CONTAINS THE DIRECT ADDRESS        02169000 D
                                                                        * A1,A2,A3,AMPCR MUST BE SAVED TO BE USED02170000 D
05FF  4809 C000 0030 00FC                        A2 = MIR               * SAVE A2 IN MIR                         02171000 D
0600  4809 00C0 0000 24F0                        ASE                    * REFERENCE BR2/MAR                      02172000 D
0601  4809 0F40 AC30 00FC                        BMAR R = A2            * SAVE BR2 IN A2                         02173000 D
0602  0210 C000 0030 0090                        B = SAR; BKPT = LIT                                             02174000 D
0603  48C9 2003 C01C 00F0                        LIT = MAR2             * BREAKPOINT LOCATION IN MAR2            02175000 D
0604  A8C9 0003 0000 0CF0                        MR2; IF RDC            * PERFORM READ OF BKPT                   02176000 D
0605  AC08 00C3 0C70 00FC                        WHEN RDC THEN BEX      * B CONTAINS BREAKPOINT                  02177000 D
0606  4809 CC52 0000 C0F0                        A2 EQL B               * BR2 EQUAL BKPT                         02178000 D
0607  680B 0003 0030 00FC                        IF TRUE THEN STEP ELSE SKIP  *IF ADDRESSES MATCH STOP EXECUTION02179000 D
0608  4800 0000 0C30 00FC                        WAIT                                                            02180000 D
0609  4809 C0C1 0010 00F0                        A2 L = BR2             * RESTORE BR2                            02181000 D
060A  0000 0003 0030 0030                        COMP B = SAR                                                    02182000 D
060B  4809 0000 0000 00F0                        BMI                    * RESTORE A2 TO ORIG. CONTENTS           02183000 D
060C  280B 0C40 2030 00F0                        B = A2; IF LC1 THEN STEP ELSE SKIP * CALLING ROUTINE CHECK      02184000 D
060D  0BEC 0000 0000 C04C                        BKPTOUT - 1 = MPCR     * RETURN TO EMULOUT                      02185000 D
060E  0BFC 0000 0C30 C04C                        BKPTIN  - 1 = MPCR     * RETURN TO EMULIN                       02186000 D
                                                                        *                                        02187000 D
                                                                        *                                        02188000 D
                                       EMULIN:                          * THIS ROUTINE READS FROM MEMORY AFTER   02189000 D
                                                                        * CHECKING THE PAGING AND BREAKPOINT BITS02190000 D
                                                                        * IN SR#1.  BR2 CONTAINS THE ADDRESS TO  02191000 D
                                                                        * BE READ FROM.                          02192000 D
060F  2809 A0C0 8830 00F0                        A1 R = B; IF LC1                                                02193000 D
0610  A00C 0000 0030 C020                        22 = SAR               *                                        02194000 D
0611  4809 0C40 0030 00F0                        B                      * SEND B TO THE ADDER                    02195000 D
0612  580B 00C3 0030 00FC                        IF LST THEN STEP ELSE SKIP  * TEST PAGING BIT                   02196000 D
0613  0C00 00C3 003C C04C                        PAGING - 1 = MPCR      * JUMP IF PAGING BIT SET                 02197000 D
0614  4809 ACC0 8B0C C0F0              PAGEIN:   A1 R = B                                                        02198000 D
0615  800C 0003 C030 0020                        20 = SAR                                                        02199000 D
0616  4809 CC43 0030 C0F0                        B                      * SEND B TO THE ADDER                    02200000 D
0617  58CB 0CC0 0000 C0F0                        IF LST THEN STEP ELSE SKIP  * TEST BREAKPOINT BIT               02201000 D
0618  5FEC 0000 0000 004C                        BKTCMP - 1 = MPCR      * JUMP TO BKPT ANALYSIS ROUTINE          02202000 D
0619  4809 0000 0C00 24F0              BKPTIN:   ASE                    * REFERENCE MAR2                         02203000 D
061A  4809 0F43 801C 00F0                        BMAR R = MAR2          * SET UP MAR2 WITH ADDRESS               02204000 D
061B  0000 0000 0030 0010                        B = SAR                                                         02205000 D
061C  A809 0C00 0C00 0CFC                        MR2; BEX; IF RDC       * READ IN PRESENT ADDRESS INTO B         02206000 D
061D  AC08 0003 0000 C0F0                        WHEN RDC THEN 0                                                 02207000 D
061E  482D 0CC0 0C30 00F0                        JUMP                                                            02208000 D
                                                                        *                                        02209000 D
                                                                        *                                        02210000 D
                                       EMULOUT:                         * THIS ROUTINE WRITES OUT INTO MEMORY    02211000 D
                                                                        * AFTER CHECKING THE PAGING BIT(BIT 22)  02212000 D
                                                                        * AND THE BREAKPOINT BITS(BITS 21-20) IN 02213000 D
                                                                        * THE SR#1 PORTION OF THE FSW.  BR2      02214000 D
                                                                        * CONTAINS THE ADDRESS TO BE WRITTEN     02215000 D
                                                                        * INTO AND MIR CONTAINS THE INFO TO BE   02216000 D
                                                                        * WRITTEN.                               02217000 D
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061F  49C9 0000 0000 00F0          SET LC1                  % FLAG USED TO IDENTIFY THIS ROUTINE     02218000 D
0620  4809 0000 0000 00F0          BMI                      % TRANSFER MIR TO B                      02219000 D
0621  48C9 CC40 2000 00F0          0 = A2                   % TRANSFER B(MIR) TO A2                  02220000 D
0622  4809 A000 8B00 00F0          A1 R = B                                                          02221000 D
0623  A000 0000 0000 C020          22 = SAR                                                          02222000 D
0624  4809 CC40 0000 00F0          B                        % SEND B TO THE ADDER                    02223000 D
0625  580B 0000 0000 C0F0          IF LST THEN STEP ELSE SKIP  % CHECK IF PAGING SELECTED            02224000 D
0626  9C1C 0000 0000 004C          PAGING - 1 = MPCR        % JUMP TO PAGING ROUTINE                 02225000 D
0627  4809 A000 8000 C0FC  PAGEOUT: A1 R = B                                                          02226000 D
0628  9000 00C0 C000 0020          21 = SAR                                                          02227000 D
0629  4809 0C40 0000 00F0          B                        % TEST IF BREAKPOINT SELECTED            02228000 D
062A  5806 00C0 0000 C0F0          IF LST THEN STEP ELSE SKIP                                        02229000 D
062B  5FFC C000 0000 C040          BKTCMP - 1 = MPCR        % JUMP TO BKPT ANALYSIS ROUTINE          02230000 D
062C  48C9 00C0 0000 24F0  BKPTOUT: ASE                     % REFERENCE MAR2                         02231000 D
062D  4809 0F40 801C C0FC          BMAR R = MAR2            % MAR2 CONTAINS ADDRESS                  02232000 D
062E  0000 0000 C000 0010          8 = SAR                                                           02233000 D
062F  4809 C000 0050 00F0          A2 = MIR                 % RESTORE MIR                            02234000 D
0630  9809 00C0 0000 1CF0          MW2, IF SAI              % PERFORM WRITE INTO MEMORY              02235000 D
0631  9C08 00C0 C000 00F0          WHEN SAI THEN C, STEP                                             02236000 D
0632  2809 0C00 0000 00FC          IF LC1                   % CLEAR LC1                              02237000 D
0633  482D 0000 0000 00FC          JUMP                                                              02238000 D
                                                            %                                        02239000 D
                                                            %                                        02240000 D
                           IFETCH:                          % THIS ROUTINE WILL FETCH AN INSTRUCTION 02241000 D
                                                            % AND ENABLE A TRACE OF ALL REGISTERS IF 02242000 D
                                                            % PRESELECTED VIA A TRACE CONTROL CARD   02243000 D
0634  4809 0640 2000 0CF0          AMPCR = A2               % STORE RETURN ADDRESS                   02244000 D
0635  4809 2000 0010 00F0          LIT = MAR2                                                        02245000 D
0636  022C 0000 0000 00E0          STATUS2 = LIT                                                     02246000 D
0637  2F30 00C0 0000 0060          EINPUT - 1 = CPCR        % READ IN SR #2                          02247000 D
0638  48C9 0C40 0000 00FC          B                        % SR # 2 TO THE ADDER                    02248000 D
0639  4800 00C0 0000 00F0          IF MST THEN STEP ELSE SKIP  % TRACE IF TRUE                       02249000 D
063A  27EC 00C0 0000 0060          DUMPREG - 1 = CPCR       %JUMP TO REGISTER DUMPING ROUTINE        02250000 D
063B  4809 A001 0B00 00FC          A1 L = B                 % ISOLATE ADDRESS IN PAR FIELD OF FSW    02251000 D
063C  0000 00C0 0000 0020          COMP 16 = SAR                                                     02252000 D
063D  4809 0C40 8B00 00F0          B R = B                                                           02253000 D
063E  4809 0C41 0010 00FC          B L = BR2                % INSERT ADDRESS INTO BR2                02254000 D
063F  0000 C000 0000 C030          COMP 8 = SAR             % BR2 IS FILLED FROM 2ND LSB OF SOURCE   02255000 D
0640  60E0 C000 C000 C060          EMULIN - 1 = CPCR        % RETRIEVE INSTRUCTION AT ADDRESS IN BR2 02256000 D
0641  4809 C0C0 0030 C0FC          A2 = AMPCR               % RESTORE RETURN ADDRESS                 02257000 D
0642  4809 A001 2000 C0F0          A1 L = A2                % ISOLATE PAR INTO A2                    02258000 D
0643  0000 00C0 0000 C020          COMP 16 = SAR                                                     02259000 D
0644  48C9 C000 A000 00F0          A2 R = A2                                                         02260000 D
0645  48C9 C0C0 A000 00F0          A2 + 1 R = A2            % TEST FOR UPPER MEMORY BOUNDRY          02261000 D
0646  4809 C018 0000 C0F0          A2 GTR C                                                          02262000 D
0647  7429 A0C0 4000 C0F0          IF FALSE THEN A1 + 1 = A1; JUMP  % NORMAL INCREMENT               02263000 D
0648  4809 0C40 0030 00F0          B = MIR                                                           02264000 D
0649  4809 00C1 0B00 00F0          1 L = B                  % CREATE 1024 IN B                       02265000 D
064A  A000 0000 0000 C020          COMP 10 = SAR                                                     02266000 D
064B  4809 A0C0 C000 C0FC          A1 R = A1                                                         02267000 D
064C  0000 0000 0000 002C          16 = SAR                                                          02268000 D
064D  4809 A001 4000 0CF0          A1 L = A1                % CLEAR PAR                              02269000 D
064E  4809 AC5C 4D00 00F0          A1 OR B = A1,BMI         % RESTORE B AND SET PAR TO 1024          02270000 D
064F  482D 00C0 C000 00F0          JUMP                                                              02271000 D
                                                            %                                        02272000 D
                                                            %                                        02273000 D
                           PAGING:                          % THIS ROUTINE WILL CALCULATE AN ACTUAL  02274000 D
                                                            % ADDRESS WHEN PASSED A PAGE NUMBER      02275000 D
                                                            % REFERENCE AND AN OFFSET IN THE BR2 REG.02276000 D
                                                            % A1,A2,A3,AMPCR MUST BE SAVED TO BE USED02277000 D
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0650  4809 00C1 0000 00F0        1 L = B                   * GENERATE 512 IN B
0651  B000 0000 0000 0020        COMP 9 = SAR
0652  4809 2C46 0B00 00F0        LIT + B + 1 = B           * B NOW CONTAINS 768(ADDR OF PAGEREG)
0653  0FF0 0000 0C00 00E0        255 = LIT
0654  4809 0CC0 0030 24F0        ASE                       * REFERENCE BR2
0655  4809 0F42 8035 00F0        NOT BMAR R = CTR          * SAVE MAR(OFFSET) IN COUNTER
0656  0000 00C0 0C00 0010        B = SAR
0657  4809 0F40 801C 00F0        EMAR R = MAR2             * PUT BR2(PAGE ADDR REG NO.) IN MAR2
0658  0000 00C0 0C00 0020        16 = SAR
0659  4809 C0C0 0030 00F0        A2 = MIR                  * SAVE A2 IN MIR
065A  4809 0F40 200C 00F0        BMAR  = A2                * USE A2 AS X-SELECT HOLDER FOR BMAR
065B  4809 CC40 001C 00FC        A2 + B = MAR2             * MAR2 CONTAINS THE BASE ADDRESS OF THE
                                                           * DESIRED PAGE ADDRESS REGISTER
065C  A809 C000 0000 0CF0        MR2; IF RDC               * READ CONTENTS OF PAGE ADDR. REG.
065D  AC08 0000 0C00 00F0        WHEN RDC THEN BEX         * READ COMPLETE, STORE IN E
065E  4809 0C40 2000 0CF0        B = A2                    * SAVE PAGE ADDRESS REG CONTENTS IN A2
065F  4809 1800 8B00 00F0        B100 R = B                * SET PAGE MODIFICATION BIT (BIT 15)
0660  0C0C 00C0 0000 0020        16 = SAR
0661  2BCB C000 C00C 00FC        IF LC1 THEN SET LC1; STEP ELSE SKIP  * STORE TO MEMORY, SET
                                                           * PAGE REFERENCED BIT IN PAGE ADDR REG
0662  4809 CC5C 200C 00F0        A2 OR B = A2              * FORM PAGE ADDRESS REG PLUS MOD. BIT
0663  4809 C000 0D30 00F0        A2 = MIR,BMI              * SAVE RETURN IN B
                                                           * MODIFIED PAGE ADDR. REG. IN MIR
0664  3809 00C0 0030 1CFC        MW2; IF SAI               * WRITE OUT MODIFIED PAGE REG
0665  9C08 00C0 0000 00F0        WHEN SAI THEN 0
0666  4809 C156 2C0C 00F0        A2 AND LIT = A2           * ISOLATE PAGE NUMBER
0667  0FFC 00C0 0030 00E0        255 = LIT                 * MASK OFF LOWER 8 BITS
0668  4809 C0C0 0090 C0F0        A2 = MIR                  * RESTORE A2
0669  4809 0C40 200C 00F0        B = A2,BMI                * B HAS THE PAGE REG. CONTENTS
066A  4809 6C5D 8C10 00F0        CTR OR B C = BR2          * BR2 CONTAINS DIRECT ADDRESS (PAGING
066B  000C 0CC0 0C00 0020        16 = SAR                  * COMPLETED)
066C  2BCB C000 CC00 00FC        IF LC1 THEN SET LC1; STEP  ELSE SKIP  * ID CALLING ROUTINE
066D  5260 000D 000C 004C        PAGEOUT - 1 = MPCR        * RETURN TO EMULOUT
066E  6130 C000 0000 C040        PAGEIN - 1 = MPCR         * RETURN TO EMULIN
                                                           *
                                                           *
                                                           *
                      * * * * * * * * * * * * * * OPCODE IMPLEMENTATION * * * * * * * * * * * * * *
                                                           *
                      OPCODE:                              * THIS ROUTINE WILL FETCH AN INSTRUCTION
                                                           * ANALYZE THE OPCODE(UPPER  6 BITS)   AND
                                                           * SELECT THE CORRESPONDING ROUTINE FOR
                                                           * THE SELECTED OPERATION.
066F  4809 A0C0 0000 C0F0        A1                        * A1 TO THE ADDER
0670  4808 0000 C000 00F0        IF MST THEN STEP ELSE SKIP  * EXAMINE REMOTE EXECUTE BIT
0671  5410 0C00 000C C06C        RESTPSW - 1 = CPCR
0672  633C 0CC0 0000 006C        IFETCH - 1 = CPCR         * GET THE NEXT INSTRUCTION
0673  2809 CCC0 0090 00F0        IF LC1                    * CLEAR CONDITION BITS
0674  3809 0000 0C0C 00F0        IF LC2
0675  4809 0C40 1000 00F0        B = A3                    * SAVE INSTRUCTION INTO A3
0676  4809 0C40 AC00 00FC        B R = A2                  * PLACE THE 6 OPCODE BITS IN LOW ORDER 6
0677  200C 00C0 0030 0010        10 = SAR                  * BITS OF A2
0678  4809 C640 004C C0FC        A2 + AMPCR = AMPCR        * CREATE ADDRESS OF OPERATION ROUTINE BY
0679  0C20 000C 0C0C C0C0        OPTABLE - 1 = AMPCR       * BASE ADDRESS OF OPTABLE
067A  4809 0000 000C 00F0        STEP                      * ADDING OPCODE VALUE TO OPTABLE BASE
067B  4824 00C0 000C 00F0        EXEC                      * JUMP TO AMPCR + 1
                                                           *
                                                           *
                      OPTABLE:                             * THE FOLLOWING 64 INSTRUCTIONS CORRES-
                                                           * POND TO SUBROUTINE CALLS TO THE
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                                                         * UIN-20 INSTRUCTIONS BEING EMULATED.        02338000 D
                                                         * A1 CONTAINS THE FSW                        02339000 D
                                                         * A2 SERVES AS A TEMPORARY REGISTER          02340000 D
                                                         * FOR RETURNS, ETC.                          02341000 D
                                                         * P IS THE WORKING REGISTER                  02342000 D
                                                         * A3 CONTAINS THE INSTRUCTION                02343000 D
067C  0C30 0000 0000 0040          OPCODE00 - 1 = MPCR                                                02344000 D
067D  0C40 0000 0000 0040          OPCODE01 - 1 = MPCR                                                02345000 D
067E  0C50 0000 0000 0040          OPCODE02 - 1 = MPCR                                                02346000 D
067F  0C60 0000 0000 0040          OPCODE03 - 1 = MPCR                                                02347000 D
0680  0C70 0000 0000 0040          OPCODE04 - 1 = MPCR                                                02348000 D
0681  0C80 0000 0000 0040          OPCODE05 - 1 = MPCR                                                02349000 D
0682  0C90 0000 0000 0040          OPCODE06 - 1 = MPCR                                                02350000 D
0683  0CA0 0000 0000 0040          OPCODE07 - 1 = MPCR                                                02351000 D
0684  0CB0 0000 0000 0040          OPCODE10 - 1 = MPCR                                                02352000 D
0685  0CC0 0000 0000 0040          OPCODE11 - 1 = MPCR                                                02353000 D
0686  0CD0 0000 0000 0040          OPCODE12 - 1 = MPCR                                                02354000 D
0687  0CE0 0000 0000 0040          OPCODE13 - 1 = MPCR                                                02355000 D
0688  0CF0 0000 0000 0040          OPCODE14 - 1 = MPCR                                                02356000 D
0689  0D00 0000 0000 0040          OPCODE15 - 1 = MPCR                                                02357000 D
068A  0D10 0000 0000 0040          OPCODE16 - 1 = MPCR                                                02358000 D
068B  0D20 0000 0000 0040          OPCODE17 - 1 = MPCR                                                02359000 D
068C  0D30 0000 0000 0040          OPCODE20 - 1 = MPCR                                                02360000 D
068D  0D40 0000 0000 0040          OPCODE21 - 1 = MPCR                                                02361000 D
068E  0D50 0000 0000 0040          OPCODE22 - 1 = MPCR                                                02362000 D
068F  0D60 0000 0000 0040          OPCODE23 - 1 = MPCR                                                02363000 D
0690  0D70 0000 0000 0040          OPCODE24 - 1 = MPCR                                                02364000 D
0691  0D80 0000 0000 0040          OPCODE25 - 1 = MPCR                                                02365000 D
0692  0D90 0000 0000 0040          OPCODE26 - 1 = MPCR                                                02366000 D
0693  0DA0 0000 0000 0040          OPCODE27 - 1 = MPCR                                                02367000 D
0694  0DB0 0000 0000 0040          OPCODE30 - 1 = MPCR                                                02368000 D
0695  0DC0 0000 0000 0040          OPCODE31 - 1 = MPCR                                                02369000 D
0696  0DD0 0000 0000 0040          OPCODE32 - 1 = MPCR                                                02370000 D
0697  0DE0 0000 0000 0040          OPCODE33 - 1 = MPCR                                                02371000 D
0698  0DF0 0000 0000 0040          OPCODE34 - 1 = MPCR                                                02372000 D
0699  0E00 0000 0000 0040          OPCODE35 - 1 = MPCR                                                02373000 D
069A  0E10 0000 0000 0040          OPCODE36 - 1 = MPCR                                                02374000 D
069B  0E20 0000 0000 0040          OPCODE37 - 1 = MPCR                                                02375000 D
069C  0E30 0000 0000 0040          OPCODE40 - 1 = MPCR                                                02376000 D
069D  0E40 0000 0000 0040          OPCODE41 - 1 = MPCR                                                02377000 D
069E  0E50 0000 0000 0040          OPCODE42 - 1 = MPCR                                                02378000 D
069F  0E60 0000 0000 0040          OPCODE43 - 1 = MPCR                                                02379000 D
06A0  0E70 0000 0000 0040          OPCODE44 - 1 = MPCR                                                02380000 D
06A1  0E80 0000 0000 0040          OPCODE45 - 1 = MPCR                                                02381000 D
06A2  0E90 0000 0000 0040          OPCODE46 - 1 = MPCR                                                02382000 D
06A3  0EA0 0000 0000 0040          OPCODE47 - 1 = MPCR                                                02383000 D
06A4  0EB0 0000 0000 0040          OPCODE50 - 1 = MPCR                                                02384000 D
06A5  0EC0 0000 0000 0040          OPCODE51 - 1 = MPCR                                                02385000 D
06A6  0ED0 0000 0000 0040          OPCODE52 - 1 = MPCR                                                02386000 D
06A7  0EE0 0000 0000 0040          OPCODE53 - 1 = MPCR                                                02387000 D
06A8  0EF0 0000 0000 0040          OPCODE54 - 1 = MPCR                                                02388000 D
06A9  0F00 0000 0000 0040          OPCODE55 - 1 = MPCR                                                02389000 D
06AA  0F10 0000 0000 0040          OPCODE56 - 1 = MPCR                                                02390000 D
06AB  0F20 0000 0000 0040          OPCODE57 - 1 = MPCR                                                02391000 D
06AC  0F30 0000 0000 0040          OPCODE60 - 1 = MPCR                                                02392000 D
06AD  0F40 0000 0000 0040          OPCODE61 - 1 = MPCR                                                02393000 D
06AE  0F50 0000 0000 0040          OPCODE62 - 1 = MPCR                                                02394000 D
06AF  0F60 0000 0000 0040          OPCODE63 - 1 = MPCR                                                02395000 D
06B0  0F70 0000 0000 0040          OPCODE64 - 1 = MPCR                                                02396000 D
06B1  0F80 0000 0000 0040          OPCODE65 - 1 = MPCR                                                02397000 D
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06B2  0F90 0000 0000 0040                OPCODE66 - 1 = MPCR                                    02398000 D
06B3  0FA0 0000 0000 0040                OPCODE67 - 1 = MPCR                                    02399000 D
06B4  0FB0 0000 0000 0040                OPCODE70 - 1 = MPCR                                    02400000 D
06B5  0FC0 0000 0000 0040                OPCODE71 - 1 = MPCR                                    02401000 D
06B6  0FD0 0000 0000 0040                OPCODE72 - 1 = MPCR                                    02402000 D
06B7  0FE0 0000 0000 0040                OPCODE73 - 1 = MPCR                                    02403000 D
06B8  0FF0 0000 0000 0040                OPCODE74 - 1 = MPCR                                    02404000 D
06B9  1000 0000 0000 0040                OPCODE75 - 1 = MPCR                                    02405000 D
06BA  1010 0000 0000 0040                OPCODE76 - 1 = MPCR                                    02406000 D
06BB  1020 0000 0000 0040                OPCODE77 - 1 = MPCR                                    02407000 D
                                                                      %                         02408000 D
                                                                      %                         02409000 D
                                OPCODE00:                             % THIS ROUTINE ANALYZES 0C OPCODE   02410000 D
06BC  5F90 0000 0000 0060                XFCODE - 1 = CPCR            % "F" INTO A2             02411000 D
06BD  4809 C640 0040 00F0                A2 + AMPCR = AMPCR           % JUMP TO DESIRED SUBFUNCTION        02412000 D
06BE  1030 0000 0000 00C0                OP0CF - 1 = AMPCR            % SET UP BASE ADDR OF TYPEC0 INST.   02413000 D
06BF  4809 0000 0000 00F0                STEP                                                   02414000 D
06C0  4824 0000 0000 00F0                EXEC                                                   02415000 D
                                                                      %                         02416000 D
                                                                      %                         02417000 D
06C1  4E50 0000 0000 0040       OP00F:   NOTIMP - 1 = MPCR                                      02418000 D
06C2  3000 0000 0000 0040                FAULT - 1 = MPCR                                       02419000 D
06C3  3000 0000 0000 0040                FAULT - 1 = MPCR                                       02420000 D
06C4  1040 0000 0000 0040                OP003 - 1 = MPCR                                       02421000 D
                                                                      %                         02422000 D
                                                                      %                         02423000 D
                                OP003:                                % RX TYPE; BYTE           02424000 D
                                                                      % THIS ROUTINE STORES THE DESIGNATED BYTE02425000 D
                                                                      % OF Y INTO BITS C-7 OF R(A), AND CLEARS 02426000 D
                                                                      % THE REMAINING BITS OF R(A)         02427000 D
06C5  4849 0000 0000 00F0                SET LC2                      % SET FLAG FOR BYTE INST.            02428000 D
06C6  5700 0000 0000 0060                RXMFIELD - 1 = CPCR          % B = Y                   02429000 D
06C7  4809 0C41 0010 00F0                B L = BR2                                              02430000 D
06C8  D000 0000 0000 0030                COMP 8 = SAR                 % ADDR. OF Y IN BR2       02431000 D
06C9  60E0 0000 0000 0060                EMULIN - 1 = CPCR            % P = (Y)                 02432000 D
06CA  300B 0000 0000 00F0                IF NOT LC2 THEN STEP ELSE SKIP  % MS BYTE OF (Y)       02433000 D
06CB  4809 0C4D 8B00 00F0                B R = B                      % OR LS BYTE OF (Y)       02434000 D
06CC  DFFC 0000 0000 0090                8 = SAR; 255 = LIT                                     02435000 D
06CD  4809 2C56 0B30 00F0                LIT AND B = B,MIR            % NEW CONTENTS OR R(A)    02436000 D
06CE  20D0 0000 0000 0060                SETCCA - 1= CPCR             % ARITHMETIC CC SETTING (ENTER WITH 9)  02437000 D
06CF  4809 E000 8B00 C0F0                A3 R = B                     % ISOLATE R(A) IN LS 4 BITS          02438000 D
06D0  80FC 0000 0000 0080                4 = SAR; 15 = LIT                                      02439000 D
06D1  4809 2C56 0B30 00F0                LIT AND B = B                                          02440000 D
06D2  51C0 0000 0000 0060                REGSTACK - 1 = CPCR                                    02441000 D
06D3  2F50 0000 0000 0060                EOUTPUT - 1 = CPCR                                     02442000 D
06D4  66E0 0000 0000 0040                OPCODE - 1 = MPCR                                      02443000 D
                                                                      %                         02444000 D
                                                                      %                         02445000 D
                                OPCODE01:                             % THIS ROUTINE WILL ANALYZE 01 OPCODES.  02446000 D
                                                                      % THE INSTRUCTION MUST BE PASSED VIA THE 02447000 D
                                                                      % B REGISTER.             02448000 D
06D5  5F90 0000 0000 0060                XFCODE - 1 = CPCR            % "F" INTO A2             02449000 D
06D6  4809 C640 0040 00F0                A2 + AMPCR = AMPCR           % ADDR OF DESIRED SUBFUNCTION OF OPCODE  02450000 D
06D7  1050 0000 0000 00C0                OP01F - 1 = AMPCR            % SET UP BASE ADDR OF TYPE 01 INSTRUCTION02451000 D
06D8  4809 0000 0000 00F0                STEP                         % 01 IS DETERMINED BY ADDING THE FUNCTION02452000 D
06D9  4824 0000 0000 00F0                EXEC                         % FIELD CODE.             02453000 D
                                                                      %                         02454000 D
                                                                      %                         02455000 D
06DA  1060 0000 0000 0040       OP01F:   OP010 - 1 = MPCR             % THIS ROUTINE JUMPS TO THE APPROPRIATE  02456000 D
06DB  1070 0000 0000 0040                OP011 - 1 = MPCR             % SUBFUNCTION FOR OPCODE 01          02457000 D
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06DC   1080 0000 0000 0040               OP012 - 1 = MPCR
06DD   1090 0000 0000 0040               OP013 - 1 = MPCR
                                                                *
                                                                *
                              OP010:                            * RR TYPE INSTRUCTION
                                                                * CONTENTS OF R(M) STORED INTO R(A)
06DE   4809 2C56 0800 00FC               B AND LIT = B          * SELECT LS 4 BITS OF B ("M" FIELD)
06DF   00F0 0000 0000 00E0               15 = LIT
06E0   51CC 0000 0000 0060               REGSTACK - 1 = CPCR    * SELECT REGISTER STACK TO BE USED
                                                                * ADDR OF GEN REG STACK RETURNED IN MAR2
06E1   2F30 0000 0000 0060               EINPUT - 1 = CPCR      * PUT CONTENTS OF R(M) IN B
06E2   4809 0C40 0030 00F0               B = MIR                * CONTENTS OF R(M) IN MIR
06E3   200C 0000 0000 006C               SETCCA - 1= CPCR       * ARTHMETIC CC SETTING (ENTER WITH B)
06E4   4809 E000 9000 00F0               A3 R = A3
06E5   80FC 0000 0000 0080               4 = SAR; 15 = LIT
06E6   4809 E156 0800 00FC               A3 AND LIT = D         * OBTAIN "A" FIELD
06E7   51CC 0000 0000 006C               REGSTACK - 1 = CPCR    * SELECT REGISTER STACK TO BE USED
                                                                * ADDR OF GEN REG STACK RETURNED IN MAR2
06E8   2F50 0000 0000 0060               EOUTPUT - 1 = CPCR     * CONTENTS OF R(M) INTO R(A)
06E9   66E0 0000 0000 0040               OPCODE - 1 = MPCR
                                                                *
                                                                *
                              OP011:                            * RT TYPE IT, (Y*) INTO R(A)
06EA   4809 2C56 0800 00F0               B AND LIT = B          * OBTAIN THE "M" FIELD
06EB   00F0 0000 0000 00E0               15 = LIT
06EC   51C0 0000 0000 0060               REGSTACK - 1 = CPCR    * SELECT REGISTER STACK TO BE USED
                                                                * ADDR OF GEN REG STACK RETURNED IN MAR2
06ED   2F30 0000 0000 0060               EINPUT - 1 = CPCR      * (R(M)) = Y* PUT INTO D
06EE   4809 0C41 0C10 00FC               B L = BR2              * SET UP ADDRESS OF Y* IN BR2
06EF   000C 0000 0000 003C               COMP 8 = SAR
06F0   60E0 0000 0000 0060               EMULIN - 1 = CPCR      * READ (Y*) INTO B
06F1   4809 0C40 0030 00F0               B = MIR                * (Y*) IN MIR
06F2   200C 0000 0000 0060               SETCCA - 1= CPCR       * ARTHMETIC CC SETTING (ENTER WITH B)
06F3   4809 E000 8800 00FC               A3 R = B               * EXTRACT "A" FIELD
06F4   80F0 0000 0000 0080               4 = SAR; 15 = LIT
06F5   4809 2C56 0800 00FC               B AND LIT = B
06F6   51CC 0000 0000 0060               REGSTACK - 1 = CPCR    * SELECT REGISTER STACK TO BE USED
                                                                * ADDR OF GEN REG STACK RETURNED IN MAR2
06F7   2F50 0000 0000 0060               EOUTPUT - 1 = CPCR     * WRITE OUT CONTENTS OF Y* INTO R(A)
06F8   66E0 0000 0000 0040               OPCODE - 1 = MPCR
                                                                *
                                                                *
                              OPC12:                            * RK TYPE INSTRUCTION
                                                                * (Y) INTO R(A) IF M = 0 OR
                                                                * (Y) + (R(M)) = R(A) IF M NE 0
06F9   6330 0000 0000 006C               IFETCH - 1 = CPCR      * GET CONTENTS OF :Y: FIELD
06FA   4809 E0C1 1000 00FC               A3 L = A3              * PREPARE A3 FOR STORAGE OF :Y: FIELD
06FB   00F0 0000 0000 00A0               COMP 16 = SAR; 15 = LIT
06FC   4809 EC5C 1000 00F0               A3 OR B = A3
06FD   4809 0000 0070 00F0               C = MIR,BR2            * CLEAR MIR, BR2,
06FE   4809 E000 A000 00F0               A3 R = A2              * PLACE :M: FIELD IN LS 4 BITS OF A2
06FF   4809 C156 001C 00FC               A2 AND LIT = MAR2      * PUT :M: FIELD INTO MAR
0700   4809 0F52 000C 00F0               BMAR NEQ 0             * CHECK IF "M" FIELD 0
0701   600B 0000 0000 00F0               IF TRUE THEN STEP ELSE SKIP
0702   5670 0000 0000 006C               RM - 1 = CPCR          * ANALYZE R(M) AND RETURN VALUE IN MIR
0703   4809 E001 2000 00F0               A3 L = A2              * ISOLATE Y INTO A2
0704   000C 0000 0000 0020               COMP 16 = SAR
0705   4809 C000 AD00 00F0               A2 R = A2, BMI         * PUT Y INTO A2 AND (R(M)) INTO B
0706   4809 CC40 0030 00FC               A2 + B= B,MIR          * B,MIR CONTAINS FUTURE CONTENTS OF R(A)
0707   200C 0000 0000 0060               SETCCA - 1= CPCR       * ARTHMETIC CC SETTING (ENTER WITH B)
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0708  4809 E000 8B00 00F0             A3 R = B                   * PUT :A: FIELD IN LS 4 BITS OF B          02518000 0
0709  80F0 0000 0000 C0A0             20 = SAR; 15 = LIT                                                   02519000 0
070A  4809 2C55 0B00 00F0             LIT AND B = 0              * PUT ADDR OF R(A) INTO B                 02520000 0
070B  51C0 0000 0000 0060             REGSTACK - 1 = CPCR        * SELECT REGISTER STACK TO BE USED        02521000 0
                                                                 * ADDR OF GEN REG STACK RETURNED IN MAR2  02522000 0
070C  2F5C 0000 0000 0060             EOUTPUT - 1 = CPCR         * (R(M)) + (Y) INTO R(A)                  02523000 0
070D  66E0 0000 0000 0040             OPCODE - 1 = MPCR          * GET NEXT INSTRUCTION                    02524000 0
                                                                 *                                         02525000 0
                                                                 *                                         02526000 0
                           OP013:                                * RX TYPE INSTRUCTION                     02527000 0
                                                                 * (Y) INTO R(A)                           02528000 0
070E  5700 0000 0C00 C060             RXMFIELD - 1 = CPCR        * ANALYZE "M" FIELD CONTENTS              02529000 0
070F  4809 0C41 0010 00F0             B L = BR2                  * ISOLATE Y INTO BR2                      02530000 0
0710  000C C000 0000 0030             COMP B = SAR                                                         02531000 0
0711  60EC 0000 0000 0060             EMULIN - 1 = CPCR          * (Y) INTO B                              02532000 0
0712  4809 0C40 003C 00F0             B = MIR                    * STORE (Y) INTO MIR                      02533000 0
0713  2000 0000 0000 0060             SETCCA - 1= CPCR           * ARTHMETIC CC SETTING (ENTER WITH B)     02534000 0
0714  4809 E000 8B00 00FC             A3 R = B                                                             02535000 0
0715  80FC 0000 0000 C080             4 = SAR; 15 = LIT                                                    02536000 0
0716  4809 2C56 0B00 00F0             LIT AND B = B              * ISOLATE :A: FIELD                       02537000 0
0717  51CC 0000 0000 0060             REGSTACK - 1 = CPCR        * SELECT REGISTER STACK TO BE USED        02538000 0
                                                                 * ADDR OF GEN REG STACK RETURNED IN MAR2  02539000 0
0718  2F5C 0000 0000 0060             EOUTPUT - 1 = CPCR                                                   02540000 0
0719  66E0 0000 0000 C040             OPCODE - 1 = MPCR                                                    02541000 0
                                                                 *                                         02542000 0
                                                                 *                                         02543000 0
                           OPCODE02:                             * THIS ROUTINE  DECODES THE 02 OPCODE     02544000 0
071A  2809 0000 0000 00F0             IF LC1                                                               02545000 0
071B  3809 0000 C000 00F0             IF LC2                     * CLEARS LOCAL CONC. BITS                 02546000 0
071C  5F90 0000 0000 0060             XFCODE - 1 = CPCR                                                    02547000 0
071D  4809 C640 0040 00F0             A2 + AMPCR = AMPCR                                                   02548000 0
071E  10AC 0000 0000 00C0             OP02F - 1 = AMPCR                                                    02549000 0
071F  4809 0000 0000 00F0             STEP                                                                 02550000 0
0720  4824 0000 0000 00F0             EXEC                                                                 02551000 0
                                                                 *                                         02552000 0
0721  10B0 0000 0000 0040  OP02F:     OP020 - 1 = MPCR                                                     02553000 0
0722  10C0 0000 0000 0040             OP021 - 1 = MPCR                                                     02554000 0
0723  300C 0000 0000 C040             FAULT - 1 = MPCR                                                     02555000 0
0724  1000 0000 0000 C040             OP023 - 1 = MPCR                                                     02556000 0
                                                                 *                                         02557000 0
                           OP020:                                * UNARY FUNCTION DESCRIPTOR               02558000 0
                                                                 * :M: FIELO  SELECTS UNARY INST.          02559000 0
C725  4009 CC40 8B00 00F0             B R = B                    * ISOLATE :A: FIELO                       02560000 0
0726  90F0 0000 0000 0080             4 = SAR; 15 = LIT                                                    02561000 0
0727  4809 2C56 0B00 00F0             LIT AND B = B                                                        02562000 0
0728  51C0 C000 0000 0060             REGSTACK - 1 = CPCR                                                  02563000 0
0729  2F3C 0000 0000 C060             EINPUT - 1 = CPCR          * B = (R(A)); MAR2 = RA                   02564000 0
C72A  4809 E155 2000 C0F0             A3 AND LIT = A2                                                      02565000 0
072B  00FC 0000 0000 C0EC             15 = LIT                   * ISOLATE :M: FIELO                       02566000 0
072C  4809 C640 0040 00F0             A2 + AMPCR = AMPCR                                                   02567000 0
072D  10EC C000 0000 C0C0             OP020M - 1 = AMPCR                                                   02568000 0
072E  4809 C155 0000 00F0             A2 GEQ LIT                 * TEST FOR NOT IMPLEMENTED BOUNDRY        02569000 0
072F  00C0 0000 0000 C0E0             12 = LIT                                                             02570000 0
0730  780B 0000 0000 00F0             IF TRUE THEN STEP ELSE SKIP                                          02571000 0
0731  3000 0000 0000 0040             FAULT - 1 = MPCR                                                     02572000 0
0732  4824 0000 0000 00F0             EXEC                                                                 02573000 0
                                                                 *                                         02574000 0
0733  10F0 0000 0000 0040  OP020M:    OP02000 - 1 = MPCR                                                   02575000 0
0734  1100 0000 0000 0040             OP02001 - 1 = MPCR                                                   02576000 0
0735  1110 0000 0000 0040             OP02002 - 1 = MPCR                                                   02577000 0
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0736  3000 0000 0000 0040          FAULT - 1 = MPCR
0737  1120 0000 0000 0040          OP02004 - 1 = MPCR
0738  1130 0000 0000 0040          OP02005 - 1 = MPCR
0739  1140 0000 0000 0040          OP02006 - 1 = MPCR
073A  3000 0000 0000 0040          FAULT - 1 = MPCR
073B  1150 0000 0000 004C          OP02010 - 1 = MPCR
073C  1160 0000 0000 C04C          OP02011 - 1 = MPCR
073D  1170 0000 0000 0040          OP02012 - 1 = MPCR
073E  1180 0000 0000 0040          OP02013 - 1 = MPCR
                                                           *
                          OP02000:                         * TYPE RR; MAKE POSITIVE
                                                           * IF (R(A)) < 0, (R(A)): -> RA
                                                           * IF (R(A)) => 0, (R(A)) UNCHANGED
073F  4809 0C41 2B0C 00F0          B L = A2,B
0740  000C 0000 0000 0020          COMP 16 = SAR           * SHIFT (R(A)) TO UHW OF A2,B
0741  4809 D812 0000 00F0          A2 EQL B100             * TEST FOR MAX NEG. NUMBER
0742  6BC9 00C0 0000 C0F0          IF TRUE THEN SET LC1
0743  5C20 0000 0000 0060          OVBIT - 1 = CPCR        * SET OR CLEAR OV BIT
0744  4809 0000 0000 00F0          STEP
0745  0000 0000 0000 0020          16 = SAR
0746  4809 C000 C000 C0FC          A2                      * A2 TO THE ADDER
0747  400B 0900 0000 00F0          IF NOT MST THEN STEP ELSE SKIP
0748  66E0 0000 0000 0040          OPCODE - 1 = MPCR
0749  4849 0C5E 8B90 C0F0          -B R = B, MIR; SET LC2
074A  7BC9 0000 0000 C0F0          IF AOV THEN SET LC1     * CHECK FOR CARRY
074B  1E70 00C0 0000 C060          CARRY - 1 = CPCR
074C  38CB 00C0 0000 00FC          IF LC2 THEN STEP ELSE SKIP  * LC2 INDICATES WHETHER RA
074D  2F5C 0000 0000 C060          EOUTPUT - 1 = CPCR      * MUST BE UPDATED
074E  2000 0000 0000 0060          SETCCA - 1 = CPCR       * B CONTAINS (RA)
074F  66EC 0000 0000 0040          OPCODE - 1 = MPCR
                                                           *
                          OP02001:                         * TYPE RR; MAKE NEGATIVE
                                                           * IF (R(A)) > 0, (R(A)): -> RA
                                                           * IF (R(A)) <= 0, (R(A)) UNCHANGE
0750  4809 0C41 2B00 0CF0          B L = A2,B              * (R(A)) INTO UHW OF A2,B
0751  0000 0000 0000 C020          COMP 16 = SAR
0752  4809 C000 0000 C0F0          A2                      * A2 TO THE ADDER
C753  4419 C012 0000 00F0          IF NOT MST THEN A2 EQL 0; SKIP
0754  56E0 0000 0000 C040          OPCODE - 1 = MPCR
0755  580B 0000 0000 00F0          IF TRUE THEN STEP ELSE SKIP
0756  56E0 0000 0000 004C          OPCODE - 1 = MPCR
0757  4849 0C5E 8B90 0CFC          -B R = B, MIR; SET LC2
0758  7BC9 00C0 0000 00F0          IF AOV THEN SET LC1     * CHECK FOR CARRY
0759  1E70 0000 0000 C060          CARRY - 1 = CPCR
075A  380B 0000 0000 C0FC          IF LC2 THEN STEP ELSE SKIP
075B  2F50 0000 0000 006C          EOUTPUT - 1 = CPCR      *(R(A)): -> RA ONLY IF LC2 IS SET
075C  20DC 0000 0000 0060          SETCCA - 1 = CPCR       * B = (R(A)) OR (R(A)):
075D  56E0 C000 0000 C040          OPCODE - 1 = MPCR
                                                           *
                          OP02002:                         * ROUND TYPE RR
                                                           * IF (R(A)) >= 0 (R(A))+(R(A+1))15 -> RA
                                                           * IF (R(A)) < 0 (R(A))-(R(A+1))15 -> RA
                                                           * RA MUST BE EVEN
075E  48C9 0C41 200C 00F0          B L = A2                * B = (R(A)); MAR2 = RA
075F  0010 0000 0000 00AC          COMP 16 = SAR; 1 = LIT
0760  4809 2F5C 0B00 00F0          LIT OR BMAR = B         * R(A+1)
0761  51C0 0000 0000 C060          REGSTACK - 1 = CPCR     * R(A+1) INTO MAR2
C762  2F3C C000 C000 006C          EINPUT - 1 = CPCR       * B = (R(A+1))
C763  4809 C0C0 0000 00F0          A2
C764  4819 0000 0000 C0FC          IF MST THEN SKIP
```

```
0765  119C 0000 0000 0040             RPOS - 1 = MPCR
                                                            *
0766  4809 0C42 0B00 00F0   RNEG:     NOT B = B             * COMPLEMENT B (1:S)
0767  4809 0C40 8B00 00F0             B R = B               * ISOLATE BIT 15 IN D
0768  8000 0000 0000 0010             15 = SAR
0769  4809 0C41 0B00 00F0             B L = B               * CLEAN OUT B REGISTER
076A  1000 C000 0000 0000             COMP 31 = SAR
076B  4809 0C40 8D00 C0F0             B R = B               * PLACE BIT 15 IN BIT 16
076C  8000 0000 0000 0010             15 = SAR
076D  4849 CC5E 0090 00F0             A2 - B = MIR; SET LC2
076E  7BC9 0000 0000 C0F0             IF AOV THEN SET LC1   * CHECK FOR CARRY
076F  1E70 0000 0000 0060             CARRY - 1 = CPCR
0770  4F10 0000 0000 C060             CHECKOV - 1 = CPCR    * OVERFLOW CHECK
0771  11AC 0000 0000 004C             END02002 - 1 = MPCR
                                                            *
0772  48C9 0C41 0D0C C0F0   RPOS:     D L = B               * SHIFT BIT POS 15 OF RA+1 INTO BIT 16
0773  8000 0000 0000 0030             COMP 1 = SAR
0774  4809 CC40 CC9C 00F0             A2 + B = MIR
0775  7DC9 C000 0000 00F0             IF AOV THEN SET LC1   * CHECK FOR CARRY
0776  1E70 C000 0000 C060             CARRY - 1 = CPCR
0777  4F10 0000 0000 006C             CHECKOV - 1 = CPCR    * CHECK FOR OVERFLOW
0778  48C9 0000 0000 24F0   END02002:ASE
0779  4809 0F40 2000 C0F0             BMAR = A2             * SET UP R(A) INTO MAR2
077A  4809 C0CE 001C 00F0             A2 AND B110 = MAR2, BMI * FORM RA
077B  48C9 CC4D 8D90 00F0             B R = B,MIR           * RESULT  (R(A)) STORE INTO LHW OF B,MIR
077C  0000 0000 0030 C020             16 = SAR
077D  2CD0 0000 0000 C060             SETCCA - 1 = CPCR
077E  2F50 0000 0000 0060             EOUTPUT - 1 = CPCR
077F  66EC 0000 0000 0040             OPCODE - 1 = MPCR
                                                            *
                            OP02004:                        * 2:S COMPLEMENT; TYPE RR
0780  4809 0C41 2B00 00F0             B L = A2,B            * A2,B HAVE (R(A)) IN UHW; MAR2 = RA
0781  0000 0000 0000 0020             COMP 16 = SAR
0782  4809 D812 0000 C0F0             A2 EOL B100
0783  6DC9 00C0 0000 C0F0             IF TRUE THEN SET LC1  * CHECK FOR MAX NEG. NUM.
0784  5020 0000 000C C06C             OVBIT - 1 = CPCR      * SET/CLEAR OVBIT
0785  0000 0000 0000 002C             16 = SAR
0786  48C9 0C5E 8B90 00F0             - B R = B,MIR         * TWO:S COMPLEMENT (R(A))
0787  7BC9 0000 0000 00F0             IF AOV THEN SET LC1   * CHECK FOR CARRY
0788  1E70 0000 0000 0060             CARRY - 1 = CPCR
0789  20DC C000 0000 0060             SETCCA - 1 = CPCR     * B = (R(A))
078A  2F50 0000 0000 C06C             EOUTPUT - 1 = CPCR
078B  66EC 0000 0000 004C             OPCODE - 1 = MPCR
                                                            *
                            OP02005:                        * TWO:S COMPLEMENT DOUBLE; TYPE RR
                                                            * (RA,RA+1): -> RA,RA+1
078C  4809 0000 0000 24F0             ASE                   * REF BR2
078D  4809 0F41 0020 00F0             BMAR L = BR1          * TEMP STORAGE OF R(A)
078E  000C 0000 0000 003C             COMP 8 = SAR
078F  4809 0C41 2000 C0F0             B L = A2              * B = (R(A)); MAR2 = RA
0790  001C 0000 0000 00A0             COMP 16 = SAR ; 1 = LIT
0791  48C9 2F5C 001C 00F0             LIT OR BMAR = MAR2    * R(A+1)
0792  2F30 0000 0000 C060             EINPUT - 1 = CPCR     * B = (R(A+1)) MAR2 = RA + 1
0793  4809 CC5C 2B00 00F0             A2 OR B = A2, B       * A2 = (RA,RA+1)
0794  4809 D812 0000 C0F0             A2 EOL B100
0795  6BC9 0000 0000 00FC             IF TRUE THEN SET LC1  * TEST FOR MAX NEG NUM
0796  5020 0000 0000 C06C             OVBIT - 1 = CPCR
0797  4809 0C5E 0B00 00FC             - B = B               * TWO:S COMPLEMENT OF (R(A),R(A+1))
0798  7BC9 0000 0000 00F0             IF AOV THEN SET LC1   * CHECK FOR CARRY
0799  1E70 0000 0000 C060             CARRY - 1 = CPCR
```

```
079A  4809 0C41 1000 00F0          B L = A3                 % ISOLATE (R(A+1)) INTO MIR                  02698000 D
079B  0000 0000 0030 0020          COMP 16 = SAR                                                         02699000 D
079C  4809 E000 8030 00F0          A3 R = MIR                                                            02700000 D
079D  2F5C 0000 0000 0060          FOUTPUT - 1 = CPCR                                                    02701000 D
079E  4809 0C40 8090 20F0          B R = MIR; ASR           % (R(A)) INTO MIR                            02702000 D
079F  49C9 0F40 801C 00F0          BMAR R = MAR2; SET LC1     % R(A); SET DOUBLE WORD ARITH COMPARE      02703000 D
07A0  000C 0000 0000 0010          B = SAR                                                               02704000 D
07A1  2F50 0000 0000 C060          EOUTPUT - 1 = CPCR                                                    02705000 D
07A2  2000 0000 0000 0060          SETCCA - 1 = CPCR        % B CONTAINS (R(A),R(A+1))                   02706000 D
07A3  66E0 0000 0000 0040          OPCODE - 1 = MPCR                                                     02707000 D
                                                            %                                            02708000 D
                         OP02006:                           % ONE:S COMPLEMENT; TYPE RR                  02709000 D
                                                            % (R(A)) BIT BY BIT -> RA                    02710000 D
                                                            % B = (R(A)); MAR2 = RA                      02711000 D
07A4  4809 0C43 0B30 00F0          NOT B L = B              % B = (R(A))                                 02712000 D
07A5  0000 0000 0030 0020          COMP 16 = SAR                                                         02713000 D
07A6  4809 0C40 8B30 C0F0          B R = B, MIR                                                          02714000 D
07A7  2F50 0000 0030 0060          EOUTPUT - 1 = CPCR                                                    02715000 D
07A8  2000 0000 0000 0060          SETCCA - 1 = CPCR                                                     02716000 D
07A9  66E0 0000 0030 C040          OPCODE - 1 = MPCR                                                     02717000 D
                                                            %                                            02718000 D
                         OP02010:                           % INCREMENT RA BY 1; TYPE RR                 02719000 D
                                                            % (R(A)) + 1 -> RA; SET CC                   02720000 D
                                                            % B = (R(A)) ; MAR2 = RA                     02721000 D
07AA  4809 0C41 2030 C0F0          B L = A2                                                              02722000 D
07AB  0000 0000 0000 0020          COMP 16 = SAR            % (R(A)) IN UHW OF A2                        02723000 D
07AC  48C9 00C1 0B30 C0F0          1 L = B                  % INCREMENT  IN BIT 16                       02724000 D
07AD  4809 CC40 0030 00F0          A2 + B = MIR                                                          02725000 D
07AE  7BC9 0000 C030 00F0          IF ADV THEN SET LC1      % CHECK FOR CARRY                            02726000 D
07AF  1E70 00C0 0030 C060          CARRY - 1 = CPCR                                                      02727000 D
07B0  4F10 0000 0000 0060          CHECKOV - 1 = CPCR       % CHECK FOR OVERFLOW                         02728000 D
07B1  4809 0000 0D00 00FC          BMI                                                                   02729000 D
07B2  4809 0C40 8B30 00F0          B R = B,MIR              % RESULT IN LHW OF B,MIR                     02730000 D
07B3  0000 C000 0030 C020          16 = SAR                                                              02731000 D
07B4  2000 C0C0 0000 006C          SETCCA - 1 = CPCR                                                     02732000 D
07B5  2F5C C0C0 0000 0060          EOUTPUT - 1 = CPCR                                                    02733000 D
07B6  66E0 0003 0030 C040          OPCODE - 1 = MPCR                                                     02734000 D
                                                            %                                            02735000 D
                         OP02011:                           % DECREMENT RA BY 1; TYPE RR                 02736000 D
                                                            % (R(A)) - 1 -> RA                           02737000 D
                                                            % B = (R(A)); MAR2 = RA                      02738000 D
07B7  4809 0C41 2000 00F0          B L = A2                                                              02739000 D
07B8  000C 0000 0000 0020          COMP 16 = SAR            % (R(A)) IN UHW OF A2                        02740000 D
07B9  4849 00C1 0B00 00F0          1 L = B; SET LC2         % DECREMENT VALUE IN BIT 16                  02741000 D
07BA  4809 CC5E 0030 00F0          A2 - B = MIR                                                          02742000 D
07BB  7BC9 00C0 0000 00FC          IF ADV THEN SET LC1      % CHECK IF CARRY GENERATED                   02743000 D
07BC  1E70 0000 0030 0060          CARRY - 1 = CPCR                                                      02744000 D
07BD  4F10 0000 C000 0060          CHECKOV - 1 = CPCR       % CHECK IF OV GENERATED                      02745000 D
07BE  4809 0000 0D00 C0FC          BMI                                                                   02746000 D
07BF  4809 0C40 8B30 00F0          B R = B,MIR              % RESULT INTO LHW OF B,MIR                   02747000 D
07C0  0000 0000 0C30 0020          16 = SAR                                                              02748000 D
07C1  2000 C000 0030 0060          SETCCA - 1 = CPCR                                                     02749000 D
07C2  2F5C 00C0 0000 0060          EOUTPUT - 1 = CPCR                                                    02750000 D
07C3  66EC 0000 0030 0040          OPCODE - 1 = MPCR                                                     02751000 D
                                                            %                                            02752000 D
                         OP02012:                           % INCREASE RA BY TWO; TYPE RR                02753000 D
                                                            % (R(A)) + 2 -> RA                           02754000 D
                                                            % B = (R(A)); MAR2 = RA                      02755000 D
07C4  4809 0C41 2000 00F0          B L = A2                                                              02756000 D
07C5  0020 0000 0000 00AC          COMP 16 = SAR; 2 = LIT% (R(A)) IN UHW OF A2                           02757000 D
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07C6   4809 2001 0B30 00F0            LIT L = B
07C7   4809 CC40 0C30 00F0            A2 + B = MIR
07C8   7BC9 0000 0000 00F0            IF AOV THEN SET LC1   % CHECK FOR CARRY
07C9   1E70 0000 0000 0060            CARRY - 1 = CPCR
07CA   4F10 0000 0000 0060            CHECKOV - 1 = CPCR    % CHECK FOR OVERFLOW
07CB   4809 0000 0000 00F0            BMI
07CC   4809 0C40 8B30 00F0            B R = B,MIR           % RESULT IN LHW OF B,MIR
07CD   0000 0000 0000 0020            16 = SAR
07CE   2000 0000 0000 0060            SETCCA - 1 = CPCR
07CF   2F50 0000 0000 0060            EOUTPUT - 1 = CPCR
07D0   66E0 0000 0000 0040            OPCODE - 1 = MPCR
                                                            %
                              OP02013:                      % DECREASE RA BY TWO; TYPE RR
                                                            % (RA) - 2 -> RA
                                                            % B = (RA); MAR2 = RA
07D1   4809 0C41 2000 C0F0            B L = A2
07D2   0020 0000 0000 C0A0            COMP 16 = SAR; 2 = LIT% (R(A)) IN UHW OF A2
07D3   4849 2001 0B30 00F0            LIT L = B; SET LC2    % LC2 IS SUBTRACTION FLAG
07D4   4809 CC5E 0030 00F0            A2 - B = MIR
07D5   7BC9 0000 0000 00F0            IF AOV THEN SET LC1
07D6   1E70 0000 0C00 0060            CARRY - 1 = CPCR      % SET/CLEAR CARRY BIT
07D7   4F10 0000 0C00 0060            CHECKOV - 1 = CPCR    % CHECK FOR OVERFLOW
07D8   4809 0000 0000 00F0            BMI
07D9   4809 0C40 8B30 00F0            B R = B,MIR           % RESULT IN LHW OF B AND MIR
07DA   0000 0000 0000 0020            16 = SAR
07DB   2000 0000 0000 0060            SETCCA - 1 = CPCR
07DC   2F50 0000 0000 0060            EOUTPUT - 1 = CPCR
07DD   66E0 0000 0000 0040            OPCODE - 1 = MPCR
                                                            %
                              OP021:                        % LOAD DOUBLE; TYPE RI(II)
                                                            %(Y*,Y* + 1) -> RA,RA+1; SET CC
07DE   4809 2C56 0B00 00F0            B AND LIT = B         % ISOLATE :M: FIELD
07DF   00F0 0000 0000 00E0            15 = LIT
07E0   51C0 0000 0000 0060            REGSTACK - 1 = CPCR
07E1   2F30 0000 0000 0060            EINPUT - 1 = CPCR     % B = (R(M)) = Y*
07E2   482C 0000 0000 0060            LDBLE - 1 = CPCR      % CALL LOAD DOUBLE ROUTINE
07E3   66E0 0000 0000 0040            OPCODE - 1 = MPCR
                                                            %
                              OP023:                        % LOAD DOUBLE; TYPE RX
                                                            % (Y,Y+1) -> RA,RA+1
07E4   5700 0000 0000 0060            RXMFIELD - 1 = CPCR   % B = Y
07E5   4820 0000 0000 006C            LDBLE - 1 = CPCR      % CALL LOAD DOUBLE ROUTINE
07E6   56E0 0000 0000 C04C            OPCODE - 1 = MPCR
                                                            %
                              OPCODE03:                     % THIS ROUTINE ANALYZES THE 03 OPCODE
07E7   5F90 0000 0000 C060          ' XFCODE - 1 = CPCR
07E8   4809 C640 0040 00FC            A2 + AMPCR = AMPCR
07E9   11BC 0000 0000 00CC            OP03F - 1 = AMPCR
07EA   4809 0000 0000 00F0            STEP
07EB   4824 0000 0000 C0F0            EXEC
                                                            %
07EC   11C0 0000 0000 0040    OP03F:  OP030 - 1 = MPCR
07ED   3000 0000 0000 0040            FAULT - 1 = MPCR
07EE   3000 0000 0000 0040            FAULT - 1 = MPCR
07EF   1100 C000 0000 C040            OP033 - 1 = MPCR
                              OP030:
07F0   4809 2C56 2030 00F0            B AND LIT = A2
07F1   00FC 0000 0000 00E0            15 = LIT
07F2   4809 C640 0030 00FC            A2 + AMPCR = AMPCR
07F3   11EC 0000 0000 00CC            OP030M - 1 = AMPCR
```

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07F4   4809 C155 0000 C0F0            A2 GEQ LIT                                                      02818000 D
07F5   0070 0000 0000 00E0            7 = LIT                                                         02819000 D
07F6   7800 0000 0000 00F0            IF TRUE THEN STEP ELSE SKIP                                     02820000 D
07F7   4E50 0000 0000 0040            NOTIMP - 1 = MPCR      % INSTRUCTION NOT IMPLEMENTED            02821000 D
07F8   4824 0003 0000 00F0            EXEC                                                            02822000 D
                                                             %                                        02823000 D
                                                             %                                        02824000 D
                           OP030M:                                                                    02825000 D
07F9   11F0 0000 0000 C040            OP03000 - 1 = MPCR                                              02826000 D
07FA   1200 0000 0000 0040            OP03001 - 1 = MPCR                                              02827000 D
07FB   1210 0000 0000 0040            OP03002 - 1 = MPCR                                              02828000 D
07FC   4E5C 0000 0000 0040            NOTIMP - 1 = MPCR                                               02829000 D
07FD   1220 0000 0000 0040            OP03004 - 1 = MPCR                                              02830000 D
07FE   123C 0000 0000 0040            OP03005 - 1 = MPCR                                              02831000 D
07FF   1240 0000 0000 0040            OP03006 - 1 = MPCR                                              02832000 D
                                                             %                                        02833000 D
                           OP03000:                          % EXECUTIVE RETURN (P) + 1 -> RA; HALT   02834000 D
0800   4809 E000 8B00 00F0            A3 R = B                                                        02835000 D
0801   30F0 0000 0000 C080            4 = SAR; 15 = LIT                                               02836000 D
0802   4809 2C56 0B00 00F0            LIT AND B = B          % B = :A: FIELD                          02837000 D
0803   51C0 0000 0000 0060            REGSTACK - 1 = CPCR    % RA = MAR2                              02838000 D
0804   4809 A0C1 0B00 00F0            A1 + 1 L = B           % ISOLATE PAR INTO B INCREMENTED BY 1    02839000 D
0805   0000 0000 0000 0020            COMP 16 = SAR                                                   02840000 D
0806   4809 0C40 8B30 00F0            B R = B,MIR            % (P) + 1 INTO B AND MIR                 02841000 D
0807   200C 0000 0000 C060            SETCCA - 1 = CPCR      % SET CONDITION CODE                     02842000 D
0808   2F5C 0000 0000 C060            EOUTPUT - 1 = CPCR     % (P) + 1 -> RA                          02843000 D
0809   5D6C 0000 0000 0040            STOPTIME - 1 = MPCR    % STOP MACHINE EXECUTION                 02844000 D
                                                             %                                        02845000 D
                                                             %                                        02846000 D
                           OP03001:                          % STORE (SR1) INTO RA                    02847000 D
080A   4809 E000 9000 C0F0            A3 R = A3                                                       02848000 D
080B   30F0 0000 0000 008C            4 = SAR; 15 = LIT                                               02849000 D
080C   4809 E156 0B00 00F0            A3 AND LIT = B                                                  02850000 D
080D   51CC 0000 0000 006C            REGSTACK - 1 = CPCR    % RA = MAR2                              02851000 D
080E   4809 A0C0 8B30 00F0            A1 R = B,MIR           % (SR1) INTO MIR                         02852000 D
080F   0000 0000 0000 0020            16 = SAR                                                        02853000 D
0810   200C 0000 0000 0060            SETCCA - 1 = CPCR                                               02854000 D
0811   2F5C 0000 0000 0060            EOUTPUT - 1 = CPCR     % STORE (SR1) INTO RA                    02855000 D
0812   66E0 0000 0000 0040            OPCODE - 1 = MPCR                                               02856000 D
                                                             %                                        02857000 D
                           OP03002:                          % STORE (SR2) INTO RA                    02858000 D
0813   4809 E000 9000 00F0            A3 R = A3                                                       02859000 D
0814   30FC 0000 0000 C080            4 = SAR; 15 = LIT                                               02860000 D
0815   4809 E155 0B00 00F0            A3 AND LIT = B                                                  02861000 D
0816   51C0 0000 C000 0060            REGSTACK - 1 = CPCR    % RA = MAR2                              02862000 D
0817   4809 0000 0000 24F0            ASE                                                             02863000 D
0818   4809 0F40 2000 C0F0            BMAR = A2              % RA INTO A2                             02864000 D
0819   4809 2000 001C 00FC            LIT = MAR2                                                      02865000 D
081A   022C 0000 0000 00E0            STATUS2 = LIT                                                   02866000 D
081B   2F3C 0000 0000 C060            EINPUT - 1 = CPCR      % B = SR2                                02867000 D
081C   4809 0C41 0B00 C0F0            B L = B                % ISOLATE UYK20 SR2                      02868000 D
081D   0000 0000 0000 C020            COMP 16 = SAR                                                   02869000 D
081E   4809 0C40 8C30 C0F0            B R = MIR                                                       02870000 C
081F   4809 C000 0C1C 00F0            A2 = MAR2              % TRANSFER RA INTO MAR2                  02871000 D
0820   200C 0000 0000 C060            SETCCA - 1 = CPCR                                               02872000 D
0821   2F5C 0000 0000 0060            EOUTPUT - 1 = CPCR     % (SR2) INTO RA                          02873000 D
0822   56EC 0000 0000 0040            OPCODE - 1 = MPCR                                               02874000 D
                                                             %                                        02875000 D
                                                             %                                        02876000 D
                           OP03004:                          % LOAD P; (R(A)) INTO P                  02877000 D
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0823  4809 E000 9000 00F0        A3 R = A3                                            02878000 D
0824  80F0 0000 0000 0080        4 = SAR; 15 = LIT                                    02879000 D
0825  4809 E156 0B00 00F0        A3 AND LIT = B                                       02880000 D
0826  51C0 0000 0000 0060        REGSTACK - 1 = CPCR    % RA IN MAR2                  02881000 D
0827  2F30 0000 0000 0060        EINPUT - 1 = CPCR      % B = (R(A))                  02882000 D
0828  4809 A000 C000 00F0        A1 R = A1                                            02883000 D
0829  0000 0000 0000 0020        16 = SAR                                             02884000 D
082A  4809 A001 4000 00F0        A1 L = A1              % ZERO PAR                    02885000 D
082B  4809 AC5C 4000 00F0        A1 OR B = A1           % (R(A)) INTO P UPPER 16 BITS UNTOUCHED  02886000 D
082C  66E0 0000 0000 C040        OPCODE - 1 = MPCR                                    02887000 D
                                                        %                             02888000 D
                                                        %                             02889000 D
                     OP03005:                           % LOAD SR1 : (R(A)) INTO SR1  02890000 D
082D  4809 E000 9000 00F0        A3 R = A3                                            02891000 D
082E  80F0 0000 0000 0080        4 = SAR; 15 = LIT                                    02892000 D
082F  4809 E156 0B00 C0F0        A3 AND LIT = B                                       02893000 D
0830  51C0 0000 0000 C060        REGSTACK - 1 = CPCR    % RA IN MAR2                  02894000 D
0831  2F30 0000 0000 0060        EINPUT - 1 = CPCR      % B = (R(A))                  02895000 D
0832  4809 0C41 0030 00FC        B L = MIR              % STORE (R(A)) IN UHW OF MIR  02896000 D
0833  0000 0000 0000 0020        COMP 16 = SAR                                        02897000 D
0834  4809 2001 2C00 00F0        LIT L = A2             % CREATE BIT MASK FOR LOADER TOGGLES  02898000 D
0835  307C 0000 0000 0080        7 = LIT; COMP 29 = SAR                               02899000 D
0836  4809 2001 CB00 C0F0        LIT L = B              % LOWER MASK OF SR1           02900000 D
0837  07C0 0000 C000 00A0        112 = LIT; COMP 16 = SAR                             02901000 D
0838  4809 CC5C 0B00 C0F0        A2 OR B = B            % CREATE MASK ONES IN UHW OF B  02902000 D
0839  4809 0C42 2D00 C0F0        NOT B = A2, BMI        % MASK FOR (RA)               02903000 D
083A  4809 CC56 0030 00FC        A2 AND B = MIR         % MASK OFF (RA), STORE IN MIR  02904000 D
083B  4809 C002 0B00 00F0        NOT A2 = B             % MASK FOR A1 (PSW)           02905000 D
083C  4809 AC56 2D00 00FC        A1 AND B = A2, BMI     % MASK OFF SAVED PART OF A1 INTO A2  02906000 D
083D  4809 CC5C CB00 00F0        A2 OR B = B            % CREATE NEW A1 VALUE FROM (R(A))  02907000 D
083E  4809 AC01 4000 C0F0       A1 L = A1              % CLEAR UHW OF A1              02908000 D
083F  0000 0000 0000 C020        COMP 16 = SAR                                        02909000 D
0840  4809 A000 C000 00F0        A1 R = A1              % RESTORE A1                  02910000 D
0841  4809 AC5C 4000 0CF0        A1 OR B = A1           % RESTORE A1 (ACTIVE PSW)     02911000 D
0842  66EC C000 0000 C040        OPCODE - 1 = MPCR      % UNTOUCHED                   02912000 D
                                                        %                             02913000 D
                     OP03006:                           % LOAD SR2; (R(A)) INTO SR2   02914000 D
0843  4809 E000 9C00 CCF0        A3 R = A3                                            02915000 D
0844  90F0 0000 0000 0080        4 = SAR; 15 = LIT                                    02916000 D
0845  4809 E156 0B00 00F0        A3 AND LIT = B                                       02917000 D
0846  51CC C000 0000 0060        REGSTACK - 1 = CPCR    % RA = MAR2                   02918000 D
0847  2F30 0000 0000 006C        EINPUT - 1 = CPCR      % B = (R(A))                  02919000 D
0848  4809 0C40 2C00 00F0        B = A2                 % (R(A)) = A2                 02920000 D
0849  4809 2000 0C1C 00F0        LIT = MAR2                                           02921000 D
084A  0220 0000 0000 00E0        STATUS2 = LIT                                        02922000 D
084B  2F30 0000 0000 0060        EINPUT - 1 = CPCR      % B = (STATUS2)               02923000 D
084C  4809 0C40 8B00 00F0        B R = B                % ISOLATE UPPER 16 BITS OF STATUS2  02924000 D
084D  000C 0000 0000 0020        16 = SAR                                             02925000 D
084E  4809 0C41 0B00 00F0        B L = B                                              02926000 D
084F  4809 CC5C C0B0 C0F0        A2 OR B = MIR          %  NEW STATUS2 CREATED        02927000 D
0850  2F50 0000 0000 C060        EOUTPUT - 1 = CPCR     % (R(A)) INTO STATUS2         02928000 D
0851  56E0 0000 0000 0040        OPCODE - 1 = MPCR                                    02929000 D
                                                        %                             02930000 D
                                                        %                             02931000 D
                     OP033:                             % LOAD MULTIPLE, TYPE RX      02932000 D
                                                        % (Y ... Y + M - A + 1) INTO RA ... RM  02933000 D
0852  5330 0000 0000 0060        IFETCH - 1 = CPCR      % B = :Y: = Y                 02934000 D
0853  4809 0C41 0B0C 00F0        B L = B                                              02935000 D
0854  00F0 0000 0000 00A0        COMP 16 = SAR; 15 = LIT                              02936000 D
0855  4809 EC5C 1000 00F0        A3 OR B = A3           % STORE Y IN UHW OF A3        02937000 D
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0856  4809 E156 2000 00F0              A3 AND LIT = A2          % A2 = :M: FIELD                     02938000 D
0857  4809 E003 8000 00F0              A3 R = B                                                      02939000 D
0858  9000 00C0 0030 0000              4 = SAR                                                       02940000 D
0859  4809 2C56 0600 C0F0              LIT AND B = B            % B = :A: FIELD                      02941000 D
085A  4809 CC5E 0000 C0F0              A2 LSS B                 % IF M < A THEN ADD 16               02942000 D
085B  0100 00C0 0C00 00E0              16 = LIT                                                      02943000 D
085C  700D 0000 0000 00F0              IF TRUE THEN STEP ELSE SKIP                                   02944000 D
085D  4809 C140 2030 00F0              A2 + LIT = A2                                                 02945000 D
085E  4809 CC5E 2000 00F0              A2 - B = A2              % SUBTRACT M FROM A                  02946000 D
085F  4809 C012 0030 C0F0              A2 EOL 0                 % IF M = A THEN COUNTER = 0          02947000 D
0860  6819 0000 0000 00F0              IF TRUE THEN SKIP                                             02948000 D
0861  4809 C0C0 2000 24F0              A2 + 1 = A2; ASE         % COMPUTE M - A + 1                  02949000 D
0862  5100 0000 0000 0060              REGSTACK - 1 = CPCR      % B HAS RA; MAR2 = RA                02950000 D
0863  4809 0F41 0020 40F0              BMAR L = BR1,CSAR        % SAVE RA IN BR1                     02951000 D
0864  D000 0003 0030 0030              COMP B = SAR                                                  02952000 D
0865  4809 E003 9010 C0F0              A3 R = A3,BR2            % STORE Y IN BR2                     02953000 D
0866  4809 E0C0 9030 00F0              A3 R = A3                % STORE Y IN A3; RIGHT JUSTIFIED     02954000 D
0867  60E0 00C3 0000 0060    LOMUL:    EMULIN - 1 = CPCR        % LOOP RETURN; B = (Y)               02955000 D
0868  4809 0C40 0030 C0F0              B = MIR                  % MIR = (Y)                          02956000 D
0869  4809 000D 0030 20F0              ASR                                                           02957000 D
086A  4809 0F43 8B1C C0F0              BMAR R = B,MAR2          % RA INTO B FROM BR1                 02958000 D
086B  0000 0000 0000 0010              8 = SAR                                                       02959000 D
086C  2F50 00C3 0000 0060              EOUTPUT - 1 = CPCR       % (Y) INTO RA                        02960000 D
086D  4809 0C46 0B00 C0F0              B + 1 = B                % INCREMENT RA                       02961000 D
086E  51C0 00C0 0000 C060              REGSTACK - 1 = CPCR      % COMPUTE NEXT RA INTO MAR2          02962000 D
086F  4809 0F41 0020 00F0              BMAR L = BR1             % RA + 1 = BR1                       02963000 D
0870  0000 000D 0030 0030              COMP 8 = SAR                                                  02964000 D
0871  4809 E0C0 1000 C0F0              A3 + 1 = A3              % DR2 + 1 = BR2; INCREMENT Y         02965000 D
0872  4809 E001 0010 00FC              A3 L = BR2                                                    02966000 D
0873  4809 C0DE 2000 00FC              A2 - 1 = A2              % DECREMENT COUNTER                  02967000 D
0874  4809 C012 0030 00FC              A2 EOL 0                                                      02968000 D
0875  6819 0C03 0000 00F0              IF TRUE THEN SKIP                                             02969000 D
0876  9660 C000 0C30 C040              LOMUL - 1 = MPCR                                              02970000 D
0877  66EC 000D 0030 0040              OPCODE - 1 = MPCR                                             02971000 D
                                                                %                                    02972000 D
                                                                %                                    02973000 D
                             OPCODE04:                          % THIS ROUTINE ANALYZES THE 04 OPCODE 02974000 D
0878  5F90 000D 0030 0060              XFCODE - 1 = CPCR        % :F: FIELD IN A2                    02975000 D
0879  4809 C640 0030 C0F0              A2 + AMPCR = AMPCR                                            02976000 D
087A  1250 C00D 0030 00C0              OP04F - 1 = AMPCR                                             02977000 D
087B  4809 C0C0 0030 00F0              STEP                                                          02978000 D
087C  4824 000D C030 00F0              EXEC                                                          02979000 D
                                                                %                                    02980000 D
087D  1260 0003 000C C040    OP04F:    OP040 - 1 = MPCR                                              02981000 D
087E  3000 C000 0000 C040              FAULT - 1 = MPCR                                              02982000 D
087F  3000 00C0 C000 C040              FAULT - 1 = MPCR                                              02983000 D
0880  1270 0003 0000 C040              OP043 - 1 = MPCR                                              02984000 D
                                                                %                                    02985000 D
                             OP040:                             % THIS ROUTINE ISOLATES THE :M: FIELD 02986000 D
0881  4809 2C56 2000 00FC              LIT AND B = A2                                                02987000 D
0882  00FC 0000 0000 00E0              15 = LIT                                                      02988000 D
0883  4809 C15E 0030 C0F0              A2 GEO LIT                                                    02989000 D
0884  0C4C 000D C0C0 C0E0              4 = LIT                                                       02990000 D
0885  780B 0000 0030 00FC              IF TRUE THEN STEP ELSE SKIP                                   02991000 D
0886  3000 0000 C030 C040              FAULT - 1 = MPCR                                              02992000 D
0887  4809 C640 0040 C0F0              A2 + AMPCR = AMPCR                                            02993000 D
0888  128C 0CCD 0000 00C0              OP04M - 1 = AMPCR                                             02994000 D
0889  4809 0C03 0000 00F0              STEP                                                          02995000 D
088A  4824 C0CD 0000 C0F0              EXEC                                                          02996000 D
                                                                %                                    02997000 D
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088C  12A0 0000 0000 C040          OP0401 - 1 = MPCR                                          02999000 D
088D  12B0 0000 0000 0040          OP0402 - 1 = MPCR                                          03000000 D
088E  12C0 0000 0000 C040          OP0403 - 1 = MPCR                                          03001000 D
                                                         *                                     03002000 D
                         OP0400:                         * SQUARE ROOT                         03003000 D
                                                         * SQRT(R(A),R(A+1)) = R(A+1); REM=R(A)  03004000 D
                                                         * THIS ROUTINE CALCULATES THE SQUARE ROOT03005000 D
                                                         * OF A NUMBER PASSED VIA THE B REGISTER. 03006000 D
                                                         * THE SQUARE ROOT IS RETURNED IN A3,  03007000 D
                                                         * REMAINDER IN A2.                    03008000 D
                                                         * SET OV AND CC BITS                  03009000 D
088F  4809 0C40 8800 00FC          B R = B                                                    03010000 D
0890  80FC 0000 0000 008C          15 = LIT; 4 = SAR                                          03011000 D
0891  4809 2C56 0800 00F0          LIT AND B = B           * ISOLATE "A" FIELD                03012000 D
0892  51C0 0000 0000 0060          REGSTACK - 1 = CPCR     * R(A) INTO MAR2                   03013000 D
0893  2F30 0000 0000 0060          EINPUT - 1 = CPCR       * (R(A)) INTO B                    03014000 D
0894  4809 0C41 2000 00F0          B L = A2                                                   03015000 D
0895  0000 0000 0000 C020          COMP 16 = SAR                                              03016000 D
0896  4809 0F47 0020 00F0          BMAR + 1 L = BR1        * SAVE R(A+1) IN BR1               03017000 D
0897  0000 0000 0000 C030          COMP 8 = SAR                                               03018000 D
0898  4809 0F46 0000 00F0          BMAR + 1 = B            * R(A+1)                           03019000 D
0899  51C0 0000 0000 0060          REGSTACK - 1 = CPCR     * R(A+1) INTO MAR2                 03020000 D
089A  2F30 0000 0000 C060          EINPUT - 1 = CPCR       * (R(A+1)) INTO B                  03021000 D
089B  4809 CC5C 0800 00FC          A2 OR B = B             * B = (R(A),R(A+1))                03022000 D
089C  4809 CC40 0C91 00F0          B = MIR, LCTR           * MIR USED AS TEMP STORAGE         03023000 D
089D  A0F0 0000 0000 0000          30 = SAR; 15 = LIT      * CTR SET FOR 16 ITERATIONS        03024000 D
089E  4809 0000 C010 00F0          0 = BR2                                                    03025000 D
089F  4809 C000 2C1C 00F0          C = A2,MAR2                                                03026000 D
08A0  2809 0000 0000 00F0 PAIR:    BMI; IF LC1                                                03027000 D
08A1  4809 0C40 9002 C0F0          B R = A3, INC           * FETCH NEXT MS PAIR OF DIGITS     03028000 D
08A2  A000 0C00 0000 0030          30 = SAR                                                   03029000 D
08A3  4809 EF5C 1000 00F0          A3 OR BMAR = A3         * A3 = PREV. REM/NEXT PAIR OF DIGITS  03030000 D
08A4  4809 0C41 0090 00F0          B L = MIR               * TEMP STORAGE                     03031000 D
08A5  A000 0000 C000 0030          COMP 2 = SAR            * SHIFT NEXT PAIR OF DIGITS INTO MS BITS 03032000 D
08A6  8A4B 00C0 0000 00FC          IF COV THEN SET LC2; STEP ELSE SKIP                        03033000 D
08A7  120C 0000 0C00 004C          SEND - 1 = MPCR         * FINISHED                         03034000 D
08A8  300C 0000 0000 C030          COMP 1 = SAR                                               03035000 D
08A9  4809 E012 0000 00F0          A3 EQL 0                * CHECK FOR 00 PAIR OF DIGITS      03036000 D
08AA  6C0B C0C1 2000 C0FC          IF TRUE THEN A2 L = A2; STEP ELSE SKIP                     03037000 D
08AB  99FC 0000 0000 C040          PAIR - 1 = MPCR         * EXAMINE NEXT PAIR OF DIGITS      03038000 D
08AC  4809 C0C1 C800 C0F0 SEND:    A2 L = B                * PARTIAL SORT EFFECTIVELY MULT BY 4  03039000 D
08AD  300C 0000 C000 0030          COMP 1 = SAR                                               03040000 D
08AE  4809 0C46 CB00 00FC          B + 1 = B                                                  03041000 D
08AF  48C9 EC5F 0C1C CCF0          A3 - B L = MAR2         * POTENTIAL REMAINDER              03042000 D
08B0  A00C 00C0 000C 0030          COMP 2 = SAR                                               03043000 D
08B1  4FD9 EC01 001C C0FC          IF MST THEN A3 L = MAR2; SET LC1; SKIP                     03044000 D
08B2  4809 C0DC 2000 C0FC          A2 OR 1 = A2            * BUILD PARTIAL SORT               03045000 D
08B3  4809 CCC1 2000 0CF0          A2 L = A2               * PREPARE FOR NEXT DIGIT           03046000 D
08B4  B000 C000 000C 0030          COMP 1 = SAR                                               03047000 D
08B5  3006 00C0 0000 00F0          IF NOT LC2 THEN STEP ELSE SKIP                             03048000 D
08B6  89FC 0000 0000 C040          PAIR - 1 = MPCR                                            03049000 D
08B7  2C19 E000 0800 00F0          IF LC1 THEN A3 = B; SKIP  * RESTORE REMAINDER INTO B       03050000 D
08B8  4809 0F40 8000 00FC          BMAR R = B              * RESTORE REMAINDER INTO B         03051000 D
08B9  2000 C000 0000 0000          2 = SAR                                                    03052000 D
08BA  4809 C0C0 9000 00F0          A2 R = A3               * REQUIRED TO BALANCE LAST UNUSED L SHIFT03053000 D
08BB  1000 0000 0000 0000          1 = SAR                                                    03054000 D
08BC  4809 0C40 2000 0CF0          B = A2                  * REMAINDER INTO A2                03055000 D
08BD  4809 E0C0 0890 00FC          A3 = MIR,B                                                 03056000 D
08BE  2000 0000 0000 006C          SETCCA - 1 = CPCR       * SET THE CONDITION BITS           03057000 D
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08C0  4809 0F40 801C 00FC              BMAR R = MAR2          % (RA+1)                            03059000 D
08C1  000C 0000 0000 C010              8 = SAR                                                    03060000 0
08C2  2F50 0000 0C00 0060              EOUTPUT - 1 = CPCR     % SORT INTO R(A+1)                  03061C00 C
08C3  4809 0F40 1C00 00F0              BMAR = A3                                                  03062C00 D
08C4  4809 C00E 0C1C 00F0              A3 - 1 = MAR2          % R(A)                              03063000 D
08C5  4809 C000 0090 00F0              A2 = MIR                                                   03064C00 D
08C6  2F5C 0000 C000 0060              EOUTPUT - 1 = CPCR     % REMAINDER INTO R(A)               03065C00 D
08C7  5050 00C0 0000 C060              CLEAROV - 1 = CPCR                                         03066C00 0
08C8  66E0 0000 0000 004C              OPCODE - 1 = MPCR                                          03067C00 D
                                                              %                                   03068000 D
                                                              %                                   03069C00 D
                          OP0401:                             % RVR; REVERSE REGISTER. (REVERSE RA)  03070C00 0
08C9  4809 0C40 8800 C0F0              B R = B                % :A: FIELD LS BITS OF B            03071C00 D
08CA  80FC 0000 0000 0080              4 = SAR; 15 = LIT                                          03072C00 D
08CB  4809 2C56 0B00 00FC              LIT AND 6 = B          % B = :A: FIELD                     03073C00 0
08CC  51C0 0000 000C 006C              REGSTACK - 1 = CPCR    % RA = MAR2                         03074C00 D
08CD  2F3C 00C0 0000 C060              EINPUT - 1 = CPCR      % B = (R(A))                        03075C00 D
08CE  4809 CC40 1C0C 00F0              B = A3                                                     03076C00 D
08CF  4809 0000 2C00 C0F0              0 = A2                 % ZERO A2                           03077C00 D
08D0  00E0 00C0 0C00 C0E0              14 = LIT                                                   03078C00 D
08D1  4812 00C0 0001 C0F0              LCTR; SAVE             % EXECUTE LOOP 16 TIMES             03079000 D
08D2  4809 E0C0 0000 C0F0              A3                                                         C308CC00 D
08D3  5C19 C00C 2000 00F0              IF LST THEN A2 OR 1 = A2; SKIP  % WRITE 1 INTO LSB OF A2   03081C00 0
08D4  4809 C0CE 2000 C0F0              A2 AND B110 = A2       % WRITE 0 INTO LSB OF A2            03082000 D
08D5  4809 E000 9C00 40F0              A3 R = A3,CSAR         %  MOVE (R(A)) RIGHT 1 BIT          03083C00 D
08D6  1C00 00C0 0C00 0000              1 = SAR                % BIT SHIFT VALUE                   03084000 D
08D7  9429 CC01 2002 C0F0              IF NOT COV THEN A2 L = A2,INC; JUMP                        03085000 D
08D8  4809 C000 0B90 C0F0              A2 = B,MIR             % A2 CONTAINS REVERSE REG.          C3086C00 D
08D9  2000 00C0 0000 0060              SETCCA - 1 = CPCR                                          03087C00 0
08DA  2F5C 0000 0C00 0060              EOUTPUT - 1 = CPCR                                         03088C00 D
08DB  66E0 00C0 0000 0040              OPCODE - 1 = MPCR                                          03089C00 D
                                                              %                                   03090C00 0
                          OP0402:                             % CNT; COUNT ONES; COUNT -> RA + 1  03091C00 C
08DC  4809 0C40 8800 00F0              B R = B                % :A: FIELD LS BITS OF B            03092C00 D
08DD  80F0 00C0 0000 0080              4 = SAR; 15 = LIT                                          03093C0C D
08DE  4809 2C56 CB00 00F0              LIT AND B = B                                              03094C00 D
08DF  51CC 00C0 000C C060              REGSTACK - 1 = CPCR    % RA=MAR2                           03095C00 D
08E0  2F3C 0000 0000 C060              EINPUT - 1 = CPCR      % B = (R(A))                        03096000 0
08E1  4809 C0C0 2C90 C0F0              0 = A2,MIR             % ZERO COUNT REGISTER               03097C00 D
08E2  00E0 0000 0000 00E0              14 = LIT                                                   03098000 D
08E3  4812 0000 C001 00F0              LCTR; SAVE             % EXECUTE LOOP 16 TIMES             03099C0C D
08E4  4809 0C40 0000 00F0              B                                                          0310C00C 0
08E5  5C09 C0C0 2090 00F0              IF LST THEN A2 + 1 = A2,MIR  % INCREMENT COUNTER           031C1C00 D
08E6  4809 0C40 8800 00F0              B R = B                                                    C3102C00 0
08E7  100C 0000 0000 C000              1 = SAR                % SHIFT RA RIGHT                    03103000 D
08E8  8429 0000 0072 00F0              IF NOT COV THEN INC; JUMP                                  03104C00 0
08E9  4809 CF46 0B00 00FC              BMAR + 1 = B           % R(A+1)                            03105C00 0
08EA  51CC 00C0 0C00 0060              REGSTACK - 1 = CPCR    % R(A+1) INTO MAR2                  C3106C00 C
08EB  2F50 00C0 0C0C 0060              EOUTPUT - 1 = CPCR     % STORE COUNT IN MIR INTO RA + 1    031C7C00 D
08EC  66EC C000 0000 C040              OPCODE - 1 = MPCR                                          03108C00 D
                                                              %                                   031C9C00 0
                          OP0403:                             % SFR; SCALE FACTOR. (RA,RA+1) SHIFTED  03110000 D
                                                              % LEFT UNTIL (R(A))15 NEQ (R(A))14  03111C0C D
                                                              % SHIFT COUNT -> RA+2               03112C00 D
08ED  4809 0C40 8800 00FC              B R = B                                                    03113C00 D
08EE  80FC 0000 000C C080              4 = SAR; 15 = LIT                                          03114C00 0
08EF  4809 2C56 0B00 C0F0              LIT AND B = B          % :A: FIELD INTO B                  03115C00 0
08F0  51CC 0000 0000 C060              REGSTACK - 1 = CPCR    % RA = MAR2                         03116C00 D
08F1  2F3C 0000 0000 0060              EINPUT - 1 = CPCR      % B = (R(A))                        03117C0C D
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08F2  4809 0C41 2C00 24F0            B L = A2; ASE                                03118000 D
08F3  0000 C000 0000 0020            COMP 16 = SAR                                03119000 D
08F4  4809 0F41 0020 00F0            BMAR L = BR1          % STORE RA INTO BR1    03120000 D
08F5  0000 C000 0000 0030            COMP 8 = SAR                                 03121000 D
08F6  4809 0F46 C800 00F0            DMAR + 1 = B          % R(A+1)               03122000 D
08F7  51C0 0000 0000 0060            REGSTACK - 1 = CPCR   % R(A+1) INTO MAR2     03123000 D
08F8  2F30 0000 0000 0060            EINPUT - 1 = CPCR     % B = (R(A+1))         03124000 D
08F9  4809 20C0 C090 C0F0            LIT = MIR                                    03125000 D
08FA  01F0 0000 0000 C0E0            31 = LIT                                     03126000 D
08FB  4809 CC5C 2000 24F0            A2 OR D = A2; ASE     % A2 = (RA,RA+1)       03127000 D
08FC  4809 C000 0000 00F0            A2                                           03128000 D
08FD  6419 C012 0000 00F0            IF NOT ABT THEN A2 EOL 0 ; SKIP              03129000 D
08FE  12E0 0000 0000 0040            SFTSTP - 1 = MPCR     % STOP COUNT; COUNT = 31   03130000 D
08FF  680B 0000 0000 00F0            IF TRUE THEN STEP ELSE SKIP                  03131000 D
0900  12F0 0000 0000 0040            SFTSTP - 1 = MPCR     % STOP COUNT; COUNT = 31   03132000 D
0901  4809 18C1 8B00 00F0            B101 C = B            % MASK OF TWO BITS IN D    03133000 D
0902  11E0 0000 0000 0080            1 = SAR; 30 = LIT                            03134000 D
0903  4809 0000 C03C 00F0            0 = MAR2,MIR                                 03135000 D
0904  4812 00C0 0001 00F0            LCTR; SAVE                                   03136000 D
0905  4809 CC56 9000 00F0            A2 AND B R = A3                              03137000 D
0906  A03C 0000 0000 00B0            30 = SAR; 3 = LIT                            03138000 D
0907  4809 E012 0000 C0F0            A3 EOL 0              % TEST IF BOTH BITS EOL 0  03139000 D
0908  6419 E152 0000 C0F0            IF FALSE THEN A3 EOL LIT; SKIP  % TEST IF BOTH BITS EOL 1  03140000 D
0909  130C C0C0 0000 0040            SFTCNT - 1 = MPCR     % SHIFT COUNT INCREMENTED  03141000 D
090A  6819 0000 0000 00F0            IF TRUE THEN SKIP                            03142000 D
090B  1310 0000 0000 C040            SFTSTP - 1 = MPCR     % STOP COUNT;  MIR AND B HAVE COUNT  03143000 D
090C  4809 C0C1 2000 00F0  SFTCNT:   A2 L = A2             % SHIFT (RA,RA+1) LEFT ONE POSITION  03144000 D
090D  B000 0000 0000 003C            COMP 1 = SAR                                 03145000 D
090E  4809 0F45 009C C0F0            BMAR + 1 = MAR2,MIR                          03146000 D
090F  8429 0000 0002 00F0            IF NOT COV THEN INC; JUMP                    03147000 D
0910  4809 C0C0 000C 20F0  SFTSTP:   ASR                                          03148000 D
0911  4809 0F40 9000 00F0            BMAR R = A3           % BR1 INTO A3= RA      03149000 D
0912  0020 0000 0000 0090            8 = SAR; 2 = LIT                             03150000 D
0913  4809 E140 C000 00F0            A3 + LIT = B          % B = R(A+2)           03151000 D
0914  51C0 0000 C000 0060            REGSTACK - 1 = CPCR                          03152000 D
0915  2F5C 0000 C000 C060            EOUTPUT - 1 = CPCR    % COUNT INTO RA+2      03153000 D
0916  66E0 0000 0000 C040            OPCODE - 1 = MPCR                            03154000 D
                                                           %                      03155000 D
                           OP043:                          % BLX; BYTE LOAD AND INDEX BY 1  03156000 D
0917  4849 0000 0000 00F0            SET LC2               % SET BYTE FLAG        03157000 D
0918  5700 0CC0 0000 C060            RXMFIELD - 1 = CPCR   % B = Y; LC2 INDICATES BYTE  03158000 D
0919  4809 0C41 001C C0F0            B L = BR2                                    03159000 D
091A  000C 00C0 0000 C03C            COMP 8 = SAR                                 03160000 D
091B  50E0 0000 C000 C060            EMULIN - 1 = CPCR     % B = (Y)              03161000 D
091C  0FFC 0C00 0000 0090            8 = SAR; 255 = LIT                           03162000 D
091D  3C19 2C56 0090 00FC            IF LC2 THEN LIT AND B = MIR; SKIP  % LS BYTE OF Y  03163000 D
091E  4809 0C40 803C C0F0            B R = MIR             % MS BYTE OF Y         03164000 D
091F  1CBC C000 C000 0060            AEOM - 1 = CFCR       % TEST IF A EQUAL M; B="A", A2="M"  03165000 D
0920  51C0 0000 0000 0060            REGSTACK - 1 = CPCR                          03166000 D
0921  4809 C000 0000 00F0            BMI                                          03167000 D
0922  2F50 0000 0000 0060            EOUTPUT - 1 = CPCR    % BYTE LOAD INTO RA    03168000 D
0923  2000 00C0 0000 C06C            SETCCA - 1 = CPCR                            03169000 D
0924  380B 0000 0000 C0F0            IF LC2 THEN STEP ELSE SKIP  % LC2 SET BY AEOM ROUTINE  03170000 D
0925  66E0 0CC0 C000 0040            OPCODE - 1 = MPCR                            03171000 D
0926  4809 C0C0 0800 00F0            A2 = B                                       03172000 D
0927  51C0 0000 0000 C06C            REGSTACK - 1 = CPCR   % RM = MAR2            03173000 D
0928  2F3C 0000 0000 0060            EINPUT - 1 = CPCR     % B = (R(M))           03174000 D
0929  4809 0C46 003C 00FC            B + 1 = MIR           % MIR = (R(M)) + 1     03175000 D
092A  2F50 00C0 0000 C060            EOUTPUT - 1 = CPCR                           03176000 D
092B  66EC 0000 0000 C060            OPCODE - 1 = CPCR                            03177000 D
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                                                      *                                               03179000 D
                          OPCODE05:                   * THIS ROUTINE ANALYZES THE 05 OPCODE           03180000 D
092C  5F90 0000 0000 0060           XFCODE - 1 = CPCR                                                 03181000 D
092D  4809 C640 0090 CCFC           A2 + AMPCR = AMPCR                                                03182000 D
092E  132C 0000 0000 00C0           OP05F - 1 = AMPCR                                                 03183000 D
092F  4809 C000 0000 C0F0           STEP                                                              03184000 D
0930  4824 0000 0000 C0FC           EXEC                                                              03185000 D
                                                      *                                               03186000 D
0931  133C 0000 0000 0040 OP05F:    OP050 - 1 = MPCR                                                  03187000 D
0932  1340 0000 C000 C040           OP051 - 1 = MPCR                                                  03188000 D
0933  3000 0000 0000 C04C           FAULT - 1 = MPCR                                                  03189000 D
0934  135C 0000 0000 C040           OP053 - 1 = MPCR                                                  03190000 D
                                                      *                                               03191000 D
                          OP050:                      * SBR; SET BIT 1 -> (R(A))M                     03192000 D
0935  4809 0C40 88C0 C0F0           B R = B                                                           03193000 D
0936  80F0 0000 0000 0080           4 = SAR; 15 = LIT         * B = :A: FIELD                         03194000 D
0937  4809 2C56 0800 C0F0           LIT AND B = B                                                     03195000 D
0938  51C0 0000 0000 C060           REGSTACK - 1 = CPCR       * MAR2 = RA                             03196000 D
0939  2F30 0000 0000 0060           EINPUT - 1 = CPCR         * B = (R(A))                            03197000 D
093A  4809 0C40 2C00 00F0           B = A2                                                            03198000 D
093B  4809 E156 0BD0 00F0           A3 AND LIT = B            * B = :M: FIELD                         03199000 D
093C  00F0 0000 0000 00E0           15 = LIT                                                          03200000 D
093D  4809 0C5E 0000 80F0           - B = SAR                 * VARIABLE SHIFT AMOUNT FOR LEFT SHIFT  03201000 D
093E  4809 00C1 0800 00F0           8001 L = B                                                        03202000 D
093F  4809 CC5C 0B3C 00F0           A2 OR B = MIR,B           * SET 1 INTO (R(A))M AND STORE INTO MIR 03203000 D
0940  2F50 0000 0000 C060           EOUTPUT - 1 = CPCR        * MODIFIED (R(A)) -> RA                 03204000 D
0941  20DC 0000 0000 0060           SETCCA - 1 = CPCR                                                 03205000 D
0942  66E0 0000 0000 0040           OPCODE - 1 = MPCR                                                 03206000 D
                                                      *                                               03207000 D
                          OP051:                      * LXI; LOAD AND INDEX BY 1;                     03208000 D
                                                      * TYPE RI(2)                                    03209000 D
0943  4809 2C56 0B30 00F0           LIT AND B = B                                                     03210000 D
0944  00F0 0000 0000 00EC           15 = LIT                  * B = :M: FIELD                         03211000 D
0945  51C0 0000 0000 0060           REGSTACK - 1 = CPCR       * MAR2 = RM                             03212000 D
0946  2F30 0000 0000 C060           EINPUT - 1 = CPCR         * (R(M)) = Y* = B                       03213000 D
                                                      *                                               03214000 D
0947  4809 0C41 CC10 C0F0 LDINX1:   B L = BR2                                                         03215000 D
0948  0C00 C000 0000 C030           COMP B = SAR                                                      03216000 D
0949  60EC 0000 0000 0060           EMULIN - 1 = CPCR         * B = (Y*) OR (Y)                       03217000 D
094A  4809 CC40 0030 00F0           B = MIR                   * MIR = (Y*) OR (Y)                     03218000 D
094B  1C80 0000 0000 006C           AEOM - 1 = CPCR           * IS A EQUAL M ; B="A", A2 = "M"        03219000 D
094C  51C0 0000 0000 0060           REGSTACK - 1 = CPCR       * RA = MAR2                             03220000 D
094D  2F50 0000 0000 0060           EOUTPUT - 1 = CPCR        * (Y) OR (Y*) -> RA                     03221000 D
094E  4809 00C0 CDD0 C0F0           BMI                                                               03222000 D
094F  20DC 0000 0000 0060           SETCCA - 1 = CPCR         * (Y) OR (Y*) -> B                      03223000 D
0950  380B C000 0000 00FC           IF LC2 THEN STEP ELSE SKIP  * LC2 SET IN AEOM                     03224000 D
0951  56E0 0000 C000 C040           OPCODE - 1 = MPCR                                                 03225000 D
0952  4809 C000 CB00 00F0           A2 = B                                                            03226000 D
0953  51C0 0000 0000 0060           REGSTACK - 1 = CPCR                                               03227000 D
0954  2F3C 0000 0000 0060           EINPUT - 1 = CPCR         * B = (R(M))                            03228000 D
0955  4809 0C45 C030 00F0           B + 1 = MIR               * MIR = (R(M)) + 1                      03229000 D
0956  2F50 0000 0000 0060           EOUTPUT - 1 = CPCR                                                03230000 D
0957  56E0 0000 0000 0040           OPCODE - 1 = MPCR                                                 03231000 D
                                                      *                                               03232000 D
                          OP053:                      * LX; LOAD AND INDEX BY 1                       03233000 D
                                                      * TYPE RX                                       03234000 D
0958  5700 0000 0000 C060           RXMFIELD - 1 = CPCR       * B = Y                                 03235000 D
0959  946C 0000 0000 C040           LDINX1 - 1 = MPCR         * LOAD AND INDEX BY 1                   03236000 D
                                                      *                                               03237000 D
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                                  OPCODE06:                           * THIS ROUTINE ANALYZES THE 06 OPCODE    03238000 D
095A  5F90 0000 0000 0060                   XFCODE - 1 = CPCR                                                   03239000 D
095B  4809 C640 0040 00F0                   A2 + AMPCR = AMPCR                                                  03240000 D
095C  1360 0000 0000 00C0                   OP06F - 1 = AMPCR                                                   03241000 D
095D  4809 0000 0000 00F0                   STEP                                                                03242000 D
095E  4824 0000 0000 00F0                   EXEC                                                                03243000 D
                                                                      *                                         03244000 D
095F  1370 0000 0000 0040     OP06F:        OP060 - 1 = MPCR                                                    03245000 D
0960  1380 0000 0000 0040                   OP061 - 1 = MPCR                                                    03246000 D
0961  3000 0000 0000 0040                   FAULT - 1 = MPCR                                                    03247000 D
0962  1390 0000 0000 0040                   OP063 - 1 = MPCR                                                    03248000 D
                                                                      *                                         03249000 D
                              OP060:                                  * ZBR; ZERO BIT; C -> (R(A))M             03250000 D
0963  4809 0C40 8800 00F0                   0 R = B                                                             03251000 D
0964  80F0 0000 0000 0080                   4=SAR; 15=LIT                                                       03252000 D
0965  4809 2C56 0B00 00F0                   LIT AND B = B             * B = :A: FIELD                           03253000 D
0966  51C0 0000 0000 0060                   REGSTACK - 1 = CPCR                                                 03254000 D
0967  2F30 0000 0000 0060                   EINPUT - 1 = CPCR         * B = (R(A))                              03255000 D
0968  4809 0C40 2000 C0F0                   B = A2                                                              03256000 D
0969  4809 E156 0B00 00F0                   A3 AND LIT = B            * B = :M: FIELD                           03257000 D
096A  0CF0 0000 0000 00E0                   15 = LIT                                                            03258000 D
096B  4809 2C5E 0000 80F0                   LIT - B = SAR             * VARIABLE SHIFT AMOUNT FOR RIGHT SHIFT   03259000 D
096C  0200 0000 0000 00E0                   32 = LIT                                                            03260000 D
096D  4809 0CD9 8B00 00F0                   B110 C = B                * MASK                                    03261000 D
096E  4809 CC56 0B50 C0F0                   A2 AND B = MIR,B          * C -> (R(A))M                            03262000 D
096F  2F50 0000 0000 C060                   EOUTPUT - 1 = CPCR        * MODIFIED (R(A)) -> RA                   03263000 D
0970  66E0 0000 0000 0040                   OPCODE - 1 = MPCR                                                   03264000 D
                                                                      *                                         03265000 D
                              OP061;                                  * LDXI; LOAD DOUBLE (INDIRECT)            03266000 D
                                                                      * INDEX BY TWO; RI(2)                     03267000 D
0971  4809 2C56 0B00 00F0                   LIT AND B = B                                                       03268000 D
0972  00F0 0000 0000 00E0                   15 = LIT                                                            03269000 D
0973  51C0 0000 0000 0060                   REGSTACK - 1 = CPCR                                                 03270000 D
0974  2F30 0000 0000 0060                   EINPUT - 1 = CPCR         * B = (R(M)) = Y*                         03271000 D
0975  4820 0000 0000 0060                   LDBLE - 1 = CPCR                                                    03272000 D
                                                                      *                                         03273000 D
0976  1CB0 0000 0000 0060     LDINX2:       AEOM - 1 = CPCR                                                     03274000 D
0977  48C9 C000 0B00 00F0                   A2 = B                                                              03275000 D
0978  3806 0000 0000 00F0                   IF LC2 THEN STEP ELSE SKIP  * :A: = :M:                             03276000 D
0979  66E0 0000 0000 C040                   OPCODE - 1 = MPCR                                                   03277000 D
097A  51C0 0000 0000 C060                   REGSTACK - 1 = CPCR       * RM = MAR2                               03278000 D
097B  2F30 0000 0000 0060                   EINPUT - 1 = CPCR         * B = (R(M))                              03279000 D
097C  4809 2C40 C050 C0F0                   LIT + B = MIR                                                       03280000 D
097D  0020 C000 0000 00E0                   2 = LIT                                                             03281000 D
097E  2F50 0000 0000 0060                   EOUTPUT - 1 = CPCR        * (R(M)) + 2 -> RM                        03282000 D
097F  66E0 0000 0000 0060                   OPCODE - 1 = CPCR                                                   03283000 D
                                                                      *                                         03284000 D
                              OP063:                                  * LDX; LOAD DOUBLE, INDEX BY TWO          03285000 D
                                                                      * TYPE RX                                 03286000 D
0980  5700 0000 0000 C060                   RXMFIELD - 1 = CPCR       * B = Y                                   03287000 D
0981  4820 0000 0000 C060                   LDBLE - 1 = CPCR          * LOAD DOUBLE                             03288000 D
0982  9750 0000 0000 0040                   LDINX2 - 1 = MPCR         * INDEX BY TWO                            03289000 D
                                                                      *                                         03290000 D
                                                                      *                                         03291000 D
                              OPCODE07:                               * THIS ROUTINE ANALYZES THE 07 OPCODE     03292000 D
0983  5F90 0000 0000 0060                   XFCODE - 1 = CPCR                                                   03293000 D
0984  4809 C640 0030 00F0                   A2 + AMPCR = AMPCR                                                  03294000 D
0985  13AC 0000 0000 00C0                   OP07F - 1 = AMPCR                                                   03295000 D
0986  4809 0000 0000 C0F0                   STEP                                                                03296000 D
0987  4824 0000 0000 00F0                   EXEC                                                                03297000 D
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0988  13BC 0000 0030 C040   OP07F:   OP070 - 1 = MPCR                                              03299000 D
0989  13C0 0000 0000 C040            OP071 - 1 = MPCR                                              03300000 D
098A  3000 0000 0000 0040            FAULT - 1 = MPCR                                              03301000 D
098B  13D0 0000 0000 C040            OP073 - 1 = MPCR                                              03302000 D
                                                                %                                  03303000 D
                            OP070:                              % CBR; COMPARE BIT; TEST BIT M OF RA FOR 03304000 D
                                                                % ZERO                             03305000 D
098C  4809 0C40 8B00 C0F0            B R = B                                                       03306000 D
098D  80F0 C000 C000 0080            4 = SAR; 15 = LIT                                             03307000 D
098E  4809 2C56 0B00 C0F0            LIT AND B = B                                                 03308000 D
098F  51C0 0000 0000 C060            REGSTACK - 1 = CPCR        % RA = MAR2                        03309000 D
0990  2F30 C000 0000 C060            EINPUT - 1 = CPCR          % B = (R(A))                       03310000 D
0991  4809 0C40 2000 C0F0            B = A2                                                        03311000 D
0992  4809 E156 0800 C0F0            A3 AND LIT = B             % ISOLATE :M: FIELD                03312000 D
0993  00FC 0000 0000 00E0            15 = LIT                                                      03313000 D
0994  4809 CC40 000C 80F0            B = SAR                    % SHIFT COMPARE BIT TO LS POSITION 03314000 D
0995  4809 C000 A000 C0F0            A2 R = A2                                                     03315000 D
0996  4809 C000 0C00 00F0            A2                                                            03316000 D
0997  5808 0000 0000 00F0            IF LST THEN STEP ELSE SKIP  % TEST BIT                        03317000 D
0998  13E0 C000 0000 0040            TEST1 - 1 = MPCR           % TEST FOR 1 TRUE                  03318000 D
0999  4809 2C52 0000 00F0            LIT EQL B                  %  BIT POSITION 15?                03319000 D
C99A  6C19 1809 8B00 00FC            IF TRUE THEN B010 C = B; SKIP  % SET 00 INTO CC BITS          03320000 D
099B  4809 1813 8B00 00F0            B011 C = B                 % SINGLE BIT SET TO 0              03321000 D
099C  0C00 0000 0000 0010            B = SAR                                                       03322000 D
099D  4809 AC56 4000 00F0            A1 AND B = A1              % SET 0 OR 00 INTO CC BITS         03323000 D
099E  66EC 0000 0000 C040            OPCODE - 1 = MPCR                                             03324000 D
                                                                %                                  03325000 D
099F  4809 2C52 000C 00F0   TEST1:   LIT EQL B                  % BIT POSITION 15?                 03326000 D
09A0  6C19 18C1 8B00 0CF0            IF TRUE THEN B101 C = B; SKIP  % SET 11 IN BOTH CC BITS       03327000 D
09A1  4809 18C1 8B00 C0F0            B100 C = B                 % SET 1 INTO LS BIT OF CC          03328000 D
09A2  0000 0000 0000 0010            B = SAR                                                       03329000 D
09A3  4809 AC5C 4000 00F0            A1 OR B = A1               % SET 1 OR 11 INTO CC BIT          03330000 D
09A4  66E0 0000 C000 0040            OPCODE - 1 = MPCR                                             03331000 D
                                                                %                                  03332000 D
                            OP071:                              % LPI; LOAD PSW (INDIRECT)         03333000 D
                                                                % (Y*,Y*+1,Y*+2) -> P,SR1,SR2      03334000 D
09A5  4809 2C56 0B00 00F0            LIT AND B = B                                                 03335000 D
09A6  00F0 0000 0000 00E0            15 = LIT                                                      03336000 D
09A7  51C0 0000 0000 0060            REGSTACK - 1 = CPCR        % RM = MAR2                        03337000 D
09A8  2F3C 0000 0C00 0060            EINPUT - 1 = CPCR          % B = (R(M)) = Y*                  03338000 D
09A9  4809 0C40 200C 00FC   LPSW:    B = A2                     % STORE B IN A2                    03339000 D
09AA  4809 0C41 001C 00FC            B L = BR2                  % Y* = BR2 OR Y = BR2              03340000 D
09AB  000C 0000 0C0C C030            COMP 8 = SAR                                                  03341000 D
09AC  60E0 0000 0C00 006C            EMULIN - 1 = CPCR          % B = (Y*) OR (Y)                  03342000 D
09AD  4809 A0C0 C000 00F0            A1 R = A1                                                     03343000 D
09AE  000C 0000 0C00 C020            16 = SAR                                                      03344000 D
09AF  4809 A0C1 4C00 00F0            A1 L = A1                                                     03345000 D
09B0  4809 AC5C 4000 00FC            A1 OR B = A1               % PAR= (Y) OR (Y*)                 03346000 D
09B1  4809 C0C0 2C00 00F0            A2 + 1 = A2                % NEXT SEQ Y OR Y*                 03347000 D
09B2  4809 C001 0C10 C0F0            A2 L = BR2                                                    03348000 D
09B3  0000 C000 000C C030            COMP 8 = SAR                                                  03349000 D
09B4  60EC 0000 0000 C060            EMULIN - 1 = CPCR          % (Y*+1) OR (Y+1) = B              03350000 D
C9B5  4809 0C41 0C9C 00F0            B L = MIR                  % STORE B INTO UHW OF MIR          03351000 D
09B6  0000 C000 000C 0020            COMP 16 = SAR                                                 03352000 D
09B7  4809 2001 1C00 00F0            LIT L = A3                 % CREATE BIT MASK FOR LOADER TOGGLES 03353000 D
09B8  3070 0000 000C 008C            7 = LIT; COMP 29 = SAR                                        03354000 D
09B9  4809 20C1 0B0C C0F0            LIT L = B                  % STORE MASK FOR LOWER SR1 INTO B  03355000 D
09BA  0700 0000 0C30 00A0            112 = LIT; COMP 16 = SAR                                      03356000 D
09BB  4809 EC5C 0B0C 00F0            A3 OR B = B                % CREATE FULL WORD MASK OF 1:S     03357000 D
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09BC  4809 0C42 1000 00F0         NOT B = A3, BMI          % MASK FOR (RA)                           03358000 D
09BD  4809 EC56 0030 00F0         A3 AND B = MIR           % MASK OFF (RA), STORE IN MIR             03359000 D
09BE  4809 E002 0B00 00F0         NOT A3 = D               % MASK FOR A1 (PSW)                       03360000 D
09BF  4809 AC56 1D00 00F0         A1 AND B = A3, BMI       % MASK OFF SAVED PART OF A1 INTO A2       03361000 D
09C0  4809 EC5C 0B70 C0F0         A3 OR D = B              % CREATE NEW A1 VALUE FROM (R(A))         03362000 D
09C1  4009 A001 4000 00F0        A1 L = A1                % CLEAR UHW OF A1                          03363000 D
09C2  0000 C000 0030 0020         COMP 16 = SAR                                                      03364000 D
09C3  4809 A000 C000 C0FC         A1 R = A1                % RESTORE A1                              03365000 D
09C4  4809 AC5C 4000 00F0         A1 OR B = A1                                                       03366000 D
09C5  4809 CCC0 2000 00F0         A2 + 1 = A2              % NEXT SEQ Y OR Y*                        03367000 D
09C6  4809 C001 0C10 00FC         A2 L = BR2                                                         03368000 D
09C7  0000 00C0 0030 0030         COMP 8 = SAR                                                       03369000 D
09C8  60E0 0000 0C00 0060         EMULIN - 1 = CPCR        % (Y*+2) OR (Y+2) = B                     03370000 D
09C9  4809 0C40 2000 00F0         D = A2                                                             03371000 D
09CA  4809 2000 001C 00F0         LIT = MAR2               % SR2 = MAR2                              03372000 D
09CB  0220 0000 0000 C0E0         STATUS2 = LIT                                                      03373000 D
09CC  2F30 0000 0000 0060         EINPUT - 1 = CPCR        % B = (STATUS2)                           03374000 D
09CD  4809 0C40 8B00 C0F0         D R = B                  % ISOLATE UPPER 16 BITS OF STATUS2        03375000 D
09CE  000C 0000 0030 C020         16 = SAR                                                           03376000 D
09CF  4809 0C41 0B00 00FC         B L = B                                                            03377000 D
09D0  4809 CC5C 009C 00F0         A2 OR B = MIR            % CREATE NEW STATUS2                      03378000 D
09D1  2F50 0000 0000 0060         EOUTPUT - 1 = CPCR                                                 03379000 D
09D2  66E0 C000 C000 0040         OPCODE - 1 = MPCR                                                  03380000 D
                                                           %                                         03381000 D
                            OP073:                         % LP; LOAD PSW                            03382000 D
                                                           % (Y,Y+1,Y+2) -> P,SR1,SR2                03383000 D
09D3  570C 0000 0000 0060         RXMFIELD - 1 = CPCR      % B = Y                                   03384000 D
09D4  9A8C 0000 0000 0040         LPSW - 1 = MPCR                                                    03385000 D
                                                           %                                         03386000 D
                                                           %                                         03387000 D
                            OPCODE10:                      % LOGICAL RIGHT SHIFT                     03388000 D
09D5  5F9C 0000 0000 0060         XFCODE - 1 = CPCR        % RETURNS "F" IN A2                       03389000 D
09D6  48C9 C640 0030 C0F0         A2 + AMPCR = AMPCR                                                 03390000 D
09D7  13FC C000 0C0C C0C0         OP10F - 1 = AMPCR                                                  03391000 D
09D8  4809 0000 0000 C0F0         STEP                                                               03392000 D
09D9  4824 0000 0000 C0F0         EXEC                                                               03393000 D
                                                           %                                         03394000 D
                                                           %                                         03395000 D
09DA  1400 0000 C000 0040   OP10F:  OP100 - 1 = MPCR                                                 03396000 D
09DB  3000 0000 0C00 0040         FAULT - 1 = MPCR                                                   03397000 D
09DC  141C 00C0 0000 0040         OP102 - 1 = MPCR                                                   03398000 D
09DD  1420 0000 0C0C 0040         OP103 - 1 = MPCR                                                   03399000 D
                                                           %                                         03400000 D
                                                           %                                         03401000 D
                            OP100:                         % RR TYPE LOGICAL RIGHT SHIFT             03402000 D
                                                           % SHIFT (R(A)) RIGHT BY THE LS 5 BITS     03403000 D
                                                           % IN (R(M)), ZERO FILL, AND SET CC        03404000 D
09DE  2380 0000 C03C 0060         CONTENTSRM - 1 = CPCR    % (R(M)) INTO B                           03405000 D
09DF  4809 0C40 0030 00F0         E = MIR                  % MIR USED AS TEMP FOR (R(M))             03406000 D
09E0  4809 E0C0 0B70 C0F0         A3 = B                                                             03407000 D
09E1  228C 0000 0000 0060         CONTENTSRA - 1 = CPCR    % (R(A)) INTO B, R(A) IN MS WORD OF A3    03408000 D
09E2  4809 0C40 1D30 00FC         B = A3, BMI                                                        03409000 D
09E3  4809 0C40 C030 80F0         B = SAR                  % SAR HOLDS BITS 0-5 OF (R(M))            03410000 D
09E4  4809 E0C0 8B8C 0CF0         A3 R = MIR, B                                                      03411000 D
09E5  20D0 0000 0C00 006C         SETCCA - 1 = CPCR        % SET CONDITION BITS                      03412000 D
09E6  2F50 0000 000C 006C         EOUTPUT - 1 = CPCR       % WRITE NEW (R(A))                        03413000 D
09E7  66E0 00C0 003C C040         OPCODE - 1 = MPCR                                                  03414000 D
                                                           %                                         03415000 D
                                                           %                                         03416000 D
                            OP102:                         % RK TYPE LOGICAL RIGHT SINGLE SHIFT      03417000 D
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                                                         * SHIFT (R(A)) RIGHT Y BITS 0-5 PLACES  03418000 D
                                                         * ZERO FILL AND SET CC                 03419000 D
09E8  6330 0000 0000 0060          IFETCH - 1 = CPCR     * Y INTO B                             03420000 D
09E9  4809 0C40 0030 C0F0          B = MIR                                                      03421000 D
09EA  4809 E156 0B00 C0F0          A3 AND LIT = B        * ISOLATE "M" FIELD                    03422000 D
09EB  00F0 0000 0000 C0E0          15 = LIT                                                     03423000 D
09EC  4809 0C52 0000 00F0          C EOL B                                                      03424000 D
C9ED  6C19 C000 0800 00F0          IF TRUE THEN 0 = D; SKIP                                     03425000 D
09EE  238C 0000 0000 C06C          CONTENTSRM - 1 = CPCR  * (R(M)) INTO B                       03426000 D
09EF  4809 0C40 2000 00F0          B = A2, BMI           * TRANSFER (R(M)) INTO A2              03427000 D
09F0  4809 CC40 0C90 00F0          A2 + B = MIR          * Y INTO MIR                           03428000 D
09F1  4809 E000 0B00 C0F0          A3 = B                * INSTRUCTION INTO B                   03429000 D
09F2  22B0 0000 000C 006C          CONTENTSRA - 1 = CPCR * (R(A)) INTO B                        03430000 D
09F3  4809 CC40 1000 00F0          B = A3, BMI           * (R(A)) INTO A3                       03431000 D
09F4  4809 0C40 0000 80F0          B = SAR               * Y(0-5) INTO SAR                      03432000 D
09F5  4809 E000 8830 0CF0          A3 R = MIR, B         * PERFORM SHIFT                        03433000 D
09F6  2F5C 0000 0C0C 0060          EOUTPUT - 1 = CPCR                                           03434000 D
09F7  200C 0000 000C C060          SETCCA - 1 = CPCR     * SET APPROPRIATE CONDITION BITS       03435000 D
C9F8  66E0 0000 000C 0040          OPCODE - 1 = MPCR                                            03436000 D
                                                         *                                      03437000 D
                                                         *                                      03438000 D
                           OP103:                        * RX TYPE BYTE STORE                   03439000 D
                                                         * (R(A)) BITS 0-7 INTO Y BYTE          03440000 D
09F9  4849 0000 000C C0F0          SET LC2               * LC2 USED AS BYTE OPERATION FLAG      03441000 D
C9FA  5700 0000 0000 006C          RXMFIELD - 1 = CPCR   * Y ADDR INTO B                        03442000 D
C9FB  4809 0C41 0010 00F0          B L = BR2             * Y INTO BR2                           03443000 D
C9FC  000C 0000 0000 003C          COMP 8 = SAR                                                 03444000 D
C9FD  4809 0F40 0020 C0F0          EMAR = BR1            * STORE Y                              03445000 D
C9FE  60EC 0000 0000 0060          EMULIN - 1 = CPCR     * (Y) INTO B                           03446000 D
09FF  4809 0C40 0C90 00F0          B = MIR               * (Y) INTO MIR                         03447000 D
0A00  4809 EC00 CB0C C0F0          A3 = B                * RESTORE INSTRUCTION INTO B           03448000 D
0A01  22B0 0000 0000 C060          CONTENTSRA - 1 = CPCR  * (R(A)) INTO B                       03449000 D
CA02  4809 2C57 100C C0F0          LIT AND B L = A3, BMI  * (R(A)) BITS (0-7) INTO 2ND LSB OF A3 03450000 D
0A03  0FFC 0000 000C 00BC          255 = LIT; COMP 8 = SAR * (Y) INTO B                         03451000 D
0A04  380B 0000 0000 0CF0          IF LC2 THEN STEP ELSE SKIP  * IF LC2 SET, PUT BYTE INTO      03452000 D
CA05  143C 0000 0C0C 0040          LS103 - 1 = MPCR      * LS BYTE OF Y                         03453000 D
0A06  4809 0C41 0B00 40F0          B L = B, CSAR         * CLEAR THE MS BYTE OF B               03454000 D
CA07  0000 0000 0000 0010          COMP 24 = SAR                                                03455000 D
0A08  4809 0C40 8800 00F0          B R = B                                                      03456000 D
CA09  4809 E000 9000 40F0          A3 R = A3, CSAR       * PUT (R(A)) -BITS 0-7 INTO 2ND LS BYTE 03457000 D
0A0A  0000 0000 0000 001C          8 = SAR               * IN A3                                03458000 D
0A0B  4809 E0C1 1000 C0F0          A3 L = A3                                                    03459000 D
0A0C  4809 EC5C 0C80 C0F0          A3 OR B = MIR         * MIR CONTAINS NEW (Y)                 03460000 D
0A0D  1440 0000 0000 0040          CNT103 - 1 = MPCR     * USED AS A "GO TO"                    03461000 D
                           LS1C3:                        * (R(A)) BITS 0-7 INTO LS BYTE OF A3   03462000 D
0A0E  4809 0C40 8800 40F0          B R = B, CSAR         * CLEAR LS BYTE OF B                   03463000 D
0A0F  000C 0000 0000 001C          8 = SAR                                                      03464000 D
0A10  4809 0C41 0B0C 40FC          B L = B, CSAR                                                03465000 D
CA11  4809 E000 900C 00F0          A3 R = A3             * (R(A)) BITS 0-7 INTO LS BYTE OF A3   03466000 D
CA12  4809 EC5C 0C90 C0F0          A3 OR B = MIR         * MIR CONTAINS NEW (Y)                 03467000 D
CA13  4809 0000 0070 20F0  CNT103: ASR                   * REFERENCE BR1                        03468000 D
CA14  4809 0F40 0010 00F0          EMAR = BR2            * Y INTO BR2                           03469000 D
0A15  61E0 0000 C000 0060          EMULOUT - 1 = CPCR    * WRITE INTO R(A)                      03470000 D
CA16  66E0 C000 0000 004C          OPCODE - 1 = MPCR                                            03471000 D
                                                         *                                      03472000 D
                                                         *                                      03473000 D
                           OPCODE11:                     * RIGHT SHIFT AND STORE                03474000 D
0A17  5F90 0000 0000 C060          XFCODE - 1 = CPCR     * "F" INTO A2                          03475000 D
0A18  4809 C640 0030 00F0          A2 + AMPCR = AMPCR                                           03476000 D
0A19  145C 0000 0000 C0C0          OP11F - 1 = AMPCR                                            03477000 D
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0A1A  4809 0000 0030 00F0            STEP                                                            03478000 D
0A1B  4824 0000 0030 00F0            EXEC                                                            03479000 D
                                                            *                                        03480000 D
                                                            *                                        03481000 D
0A1C  146C 0000 0030 0040   OP11F:   OP110 - 1 = MPCR                                                03482000 D
0A1D  147C 0000 0000 0040            OP111 - 1 = MPCR                                                03483000 D
0A1E  1480 0000 0030 0040            OP112 - 1 = MPCR                                                03484000 D
0A1F  1490 0000 0030 0040            OP113 - 1 = MPCR                                                03485000 D
                                                            *                                        03486000 D
                                                            *                                        03487000 D
                            OP110:                          * RR TYPE ALG RIGHT SINGLE SHIFT         03488000 D
                                                            * SHIFT R(A) RIGHT (R(M)) (0-5)          03489000 D
                                                            * SIGN FILL AND SET CC                   03490000 D
0A20  2380 0000 0000 0060            CONTENTSRM - 1 = CPCR  * (R(M)) INTO B                          03491000 D
0A21  4809 0C40 0030 00F0            B = MIR                * TEMP STORAGE                           03492000 D
0A22  4809 E000 0B00 00F0            A3 = B                 * PUT INSTR BACK INTO B                  03493000 D
0A23  2280 0C00 0000 0060            CONTENTSRA - 1 = CPCR  * (R(A)) INTO B                          03494000 D
0A24  4809 0C40 1000 00F0            B = A3, BMI            * (R(A)) INTO A3, (R(M)) INTO B          03495000 D
0A25  4809 E001 9030 40F0            A3 C = A3, CSAR        * POS. SIGN BIT OF (R(A)) INTO LS BIT    03496000 D
0A26  B000 0000 0000 0010            15 = SAR                                                        03497000 D
0A27  4809 E000 0000 00F0            A3                                                              03498000 D
0A28  5BC9 0000 0000 00F0            IF LST THEN SET LC1    * FLAG FOR A NEG. (R(A))                 03499000 D
0A29  4809 E001 9030 00F0            A3 C = A3              * RESTORE A3                             03500000 D
0A2A  4809 0C40 2000 00F0            B = A2                 * A2 CONTAINS (R(M))                     03501000 D
0A2B  4809 0002 0B00 00F0            NOT 0 = B              * FILL B WITH ALL 1:S                    03502000 D
0A2C  4809 0C41 0B00 00F0            B L = B                * B = 1111/0000                          03503000 D
0A2D  0000 0000 0000 0020            16 = SAR                                                        03504000 D
0A2E  2C09 EC5C 1000 00F0            IF LC1 THEN A3 OR B = A3                                        03505000 D
0A2F  4809 C000 0030 80F0            A2 = SAR               * SAR CONTAINS (R(M)) (0-5)              03506000 D
0A30  4809 E000 8B00 00F0            A3 R = B               * PERFORM ALG SHIFT                      03507000 D
0A31  4809 0C41 0B30 00F0            B L = B                * CLEAR UHW B                            03508000 D
0A32  0000 0000 0030 0C20            COMP 16 = SAR                                                   03509000 D
0A33  4809 0C40 8B30 00F0            D R = B, MIR           * RESTORE (R(A))                         03510000 D
0A34  2F5C 0000 0030 0060            EOUTPUT - 1 = CPCR     * WRITE NEW (R(A))                       03511000 D
0A35  20D0 0000 0000 0060            SETCCA - 1= CPCR       * ARTHMETIC CC SETTING (ENTER WITH B)    03512000 D
0A36  66E0 0000 0030 0040            OPCODE - 1 = MPCR                                               03513000 D
                                                            *                                        03514000 D
                                                            *                                        03515000 D
                            OP111:                          * RI TYPE 2 STORE, (R(A)) INTO Y*        03516000 D
0A37  2280 0000 0000 0060            CONTENTSRA - 1 = CPCR  * (R(A)) INTO B, R(A) INTO MS A3         03517000 D
0A38  4809 0C40 0030 00F0            B = MIR                * TEMP STORAGE OF (R(A))                 03518000 D
0A39  2380 0000 0000 0060            CONTENTSRM - 1 = CPCR  * Y* INTO B                              03519000 D
0A3A  4809 0C41 0010 00F0            B L = BR2                                                       03520000 D
0A3B  0000 0000 0030 0030            COMP 8 = SAR                                                    03521000 D
0A3C  61E0 0000 0000 0060            EMULOUT - 1 = CPCR     * (R(A)) INTO Y*                         03522000 D
0A3D  66E0 0000 0030 0040            OPCODE - 1 = MPCR                                               03523000 D
                                                            *                                        03524000 D
                                                            *                                        03525000 D
                            OP112:                          * RK TYPE, ALG, RIGHT SINGLE SHIFT       03526000 D
                                                            * SHIFT (R(A)) RIGHT Y (0-5)             03527000 D
                                                            * SIGN FILL, AND SET CC                  03528000 D
0A3E  4809 2C56 0B00 00F0            LIT AND B = B          * ISOLATE "M" FIELD                      03529000 D
0A3F  00F0 C000 0030 00E0            15 = LIT                                                        03530000 D
0A40  4809 0C52 0000 00F0            B EQL 0                                                         03531000 D
0A41  6819 C000 0000 00F0            IF TRUE THEN SKIF                                               03532000 D
0A42  2380 0000 0030 0060            CONTENTSRM - 1 = CPCR  * (R(M)) INTO B                          03533000 D
0A43  4809 0C41 0B30 00F0            B L = B                                                         03534000 D
0A44  0C00 C000 0030 0020            COMP 16 = SAR                                                   03535000 D
0A45  4809 EC5C 1000 00F0            A3 OR B = A3           * A3 = (R(M))/INSTRUCTION                03536000 D
0A46  633C 0000 0000 0060            IFETCH - 1 = CPCR      * Y INTO B                               03537000 D
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0A47  4809 E00D AC0C C0F0            A3 R = A2               * (R(M)) INTO A2                          03538000 D
0A48  0000 C0C0 0C30 0C20            16 = SAR                                                          03539000 D
0A49  4809 CC40 2000 00F0            A2 + B = A2             * Y INTO A2                               03540000 D
0A4A  4809 E00D 9000 00F0            A3 R = A3                                                         03541000 D
0A4B  30FC 0003 0000 0080            4 = SAR; 15 = LIT                                                 03542000 D
0A4C  4809 E156 0B00 C0F0            A3 AND LIT = B          * ISOLATE "A" FIELD                       03543000 D
0A4D  51C0 0000 0C00 0060            REGSTACK - 1 = CPCR     * ADDR OF R(A) INTO MAR2                  03544000 D
0A4E  2F30 C003 0C00 0060            EINPUT - 1 = CPCR       * (R(A)) INTO B                           03545000 D
0A4F  4809 0C40 903C C0F0            B R = A3                * PREPARE TO EXAMINE SIGN BIT             03546000 D
0A50  8000 0000 0000 0C10            15 = SAR                                                          03547000 D
0A51  4809 E00D 0000 00F0            A3                                                                03548000 D
0A52  5C09 0002 1000 00F0            IF LST THEN NOT 0 = A3                                            03549000 D
0A53  4809 E0C1 1C00 00F0            A3 L = A3               * A3 = 1111/0000                          03550000 D
0A54  000C 0000 0C00 0020            COMP 16 = SAR                                                     03551000 D
0A55  4809 EC5C 0B0C 00F0            A3 OR B = B             * B = 1111/(R(A)) OR 0000/(R(A))          03552000 D
0A56  4809 C0C0 0000 80F0            A2 = SAR                * Y (0-5) INTO SAR                        03553000 D
0A57  4809 0C40 8B00 00F0            B R = B                 * PERFORM ALG SHIFT                       03554000 D
0A58  4809 0C41 0B0C C0F0            B L = B                 * CLEAR UHW B                             03555000 D
0A59  000C 0000 0C0C C020            COMP 16 = SAR                                                     03556000 D
0A5A  4809 0C40 8B80 00F0            B R = B, MIR            * RESTORE SHIFTED (R(A))                  03557000 D
0A5B  2F50 C0C0 0000 0060            EOUTPUT - 1 = CPCR      * MAR2 HAS ADDR OF R(A)                   03558000 D
0A5C  2000 0C00 0000 006C            SETCCA - 1 = CPCR       * SET THE CONDITION BITS                  03559000 D
0A5D  56EC 0000 0000 C060            OPCODE - 1 = CPCR                                                 03560000 D
                                                             *                                         03561000 D
                                                             *                                         03562000 D
                           OP113:                            * RX TYPE STORE, (R(A)) INTO Y            03563000 D
0A5E  5700 00C0 0C3C 0060            RXMFIELD - 1 = CPCR     * B HOLDS ADDR OF Y                       03564000 D
0A5F  4809 0C41 0030 00F0            B L = MIR               * Y INTO MIR                              03565000 D
0A60  0C0C 0000 0C00 003C            COMP 8 = SAR                                                      03566000 D
0A61  4809 E00D 9000 00F0            A3 R = A3               * SHIFT "A" TO LS BITS                    03567000 D
0A62  30FC C0C0 0000 0080            4 = SAR; 15 = LIT                                                 03568000 D
0A63  4809 E156 CB30 00F0            A3 AND LIT = B          * "A" INTO B                              03569000 D
0A64  51C0 000D 0C30 C060            REGSTACK - 1 = CPCR     * P(A) INTO MAR2                          03570000 D
0A65  2F3C 0C00 C000 C06C            EINPUT - 1 = CPCR       * (R(A)) INTO B                           03571000 D
0A66  4809 0C40 0030 00F0            B = MIR,BMI             * (R(A)) INTO MIR                         03572000 D
0A67  4809 0C43 001C C0F0            B = BR2                 * Y INTO BR2                              03573000 D
0A68  61EC 00C3 003C 0060            EMULOUT - 1 = CPCR      * (R(A)) INTO Y                           03574000 D
0A69  66EC 0000 0030 0040            OPCODE - 1 = MPCR                                                 03575000 D
                                                             *                                         03576000 D
                                                             *                                         03577000 D
                           OPCODE12:                         * STORE AND RIGHT SHIFT                   03578000 D
0A6A  5F90 00C0 0000 C06C            XFCODE - 1 = CPCR       * "F" IN A2                               03579000 D
0A6B  4809 C640 0030 00F0            A2 + AMPCR = AMPCR                                                03580000 D
0A6C  14AC 0003 0C00 00C0            OP12F - 1 = AMPCR                                                 03581000 D
0A6D  4809 0000 CC3C 00F0            STEP                                                              03582000 D
0A6E  4824 0003 000C 00F0            EXEC                                                              03583000 D
                                                             *                                         03584000 D
                                                             *                                         03585000 D
0A6F  14BC 00C0 0000 C04C  OP12F:    OP120 - 1 = MPCR                                                  03586000 D
0A70  14C0 00C0 0C00 0040            OP121 - 1 = MPCR                                                  03587000 D
0A71  14DC C0C0 0C00 0040            OP122 - 1 = MPCR                                                  03588000 D
0A72  14EC 00C3 003C 0040            OP123 - 1 = MPCR                                                  03589000 D
                                                             *                                         03590000 D
                                                             *                                         03591000 D
                           OP120:                            * RR TYPE LOGICAL RIGHT DOUBLE SHIFT      03592000 D
                                                             * SHIFT R(A), R(A+1) RIGHT (R(M)) (0-5)   03593000 D
                                                             * ZERO FILL AND SET CC                    03594000 D
0A73  4809 0C40 8B0C C0F0            B R = B                                                           03595000 D
0A74  30F0 00C0 CC3C 0080            4 = SAR; 15 = LIT                                                 03596000 D
0A75  4809 2C56 0B00 C0F0            LIT AND B = B           * ISOLATE "A" FIELD                       03597000 D
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0A76  51C0 00C0 0000 0060        REGSTACK - 1 = CPCR     % ADDR OF R(A) INTO MAR2
0A77  4809 0F41 0020 00F0        BMAR L = BR1            % SAVE R(A)
0A78  0000 0000 0000 0030        COMP 8 = SAR
0A79  2F30 0000 0000 0060        EINPUT - 1 = CPCR       % (R(A)) INTO B
0A7A  4809 0C41 2000 00F0        B L = A2                % TEMP STORAGE OF (R(A))
0A7B  001C 0000 0000 00AC        COMP 16 = SAR; 1 = LIT
0A7C  4809 2F5C 001C 00F0        LIT OR BMAR = MAR2      % R(A+1)
0A7D  2F30 0000 0000 0060        EINPUT - 1 = CPCR       % (R(A+1)) INTO B
0A7E  4809 CC5C 2030 00F0        A2 OR B = A2            % A2 = (R(A))/(R(A+1))
0A7F  4809 E156 0B30 00F0        A3 AND LIT = B          % ISOLATE "M" FIELD
0A80  00F0 0000 0000 00EC        15 = LIT
0A81  51C0 0000 0000 0060        REGSTACK - 1 = CFCR     % R(M) INTO MAR2
0A82  2F30 0000 0000 0060        EINPUT - 1 = CPCR       % (R(M)) INTO P
0A83  4809 0C40 0030 80F0        B = SAR                 % (R(M)) ((-5) INTO SAR
0A84  49C9 C000 AB00 C0F0        A2 R = A2,B; SET LC1    % A2 HAS SHIFTED (R(A))/(R(A+1))
0A85  20DC 0000 0000 C060        SETCCA - 1 = CPCR       % SET THE CONDITION BITS
0A86  4809 00C0 0000 20F0        ASR                     % REFEFENCE BR1
0A87  4809 0F43 801C 00F0        BMAR R = MAR2           % ADDR OF R(A) INTO MAR2
0A88  0000 0000 0000 0010        8 = SAR
0A89  4609 C0C0 8090 00F0        A2 R = MIR              % (R(A)) INTO MIR
0A8A  0000 0000 0000 0020        16 = SAR
0A8B  2F50 0000 0030 0060        EOUTPUT - 1 = CPCR      % WRITE OUT SHIFTED (R(A))
0A8C  4809 C001 2030 C0F0        A2 L = A2
0A8D  0010 0000 0000 00AC        COMP 16 = SAR; 1 = LIT
0A8E  4809 C000 8090 00F0        A2 R = MIR              % (R(A+1)) INTO MIR
0A8F  4809 2F5C 001C 00F0        LIT OR BMAR = MAR2      % R(A+1)
0A90  2F5C 0000 0030 0060        EOUTPUT - 1 = CPCR
0A91  66E0 0000 0000 0040        OPCODE - 1 = MPCR
                                                         %
                                                         %
                          OP121;                         % RI TYPE 2 STORE DOUBLE
                                                         % (R(A),R(A+1)) INTO Y*, Y*+1
0A92  22B0 00C0 0000 0060        CONTENTSRA - 1 = CPCR   % (R(A)) INTO B, R(A) INTO MS WORD A3
0A93  4809 0C40 0090 00FC        B = MIR                 % TEMP STORAGE FOR (R(A))
0A94  238C 0000 0030 C060        CONTENTSRM - 1 = CPCR   % (R(M)) INTO B
0A95  4809 0C41 0010 C0F0        B L = BR2
0A96  0000 0000 0000 C030        COMP 8 = SAR
0A97  61E0 0000 0000 0060        EMULOUT - 1 = CPCR      % (R(A)) INTO Y*
0A98  4809 0F46 0090 00FC        BMAR + 1 = MIR          % TEMP HOLDER FOR Y* + 1
0A99  4809 E000 9000 40F0        A3 R = A3, CSAR
0A9A  0CF0 0000 0000 00A0        16 = SAR; 15 = LIT
0A9B  4809 E0DC 001C 00F0        A3 OR 1 = MAR2          % R(A+1)
0A9C  2F3C 0000 0000 C060        EINPUT - 1 = CPCR       % (R(A+1)) INTO B
0A9D  4809 0C40 1000 C0F0        B = A3                  % TEMP STORAGE OF (R(A))
0A9E  4809 00C0 0030 00F0        BMI
0A9F  4809 E0C0 0090 00F0        A3 = MIR
0AA0  4809 0C41 0010 C0F0        B L = BR2               % ADDR OF Y* + 1
0AA1  000C 0000 0000 C030        COMP 8 = SAR
0AA2  61EC 0000 0030 0060        EMULOUT - 1 = CPCR
0AA3  66E0 0000 000C C040        OPCODE - 1 = MPCR
                                                         %
                                                         %
                          OP122;                         % RK TYPE LOGICAL RIGHT DOUBLE SHIFT
                                                         % SHIFT (R(A), R(A+1)) RIGHT Y(0-5)
                                                         % ZEROFILL AND SET CC
0AA4  633C 0000 0000 0060        IFETCH - 1 = CPCR       % "Y" INTO B
0AA5  4809 0C41 0B30 C0F0        B L = B
0AA6  00F0 0000 0000 C0AC        16 = SAR; 15 = LIT
0AA7  4809 EC5C 1000 00F0        A3 OR B = A3            % A3 HOLDS "Y"/INSTRUCTION
0AA8  4809 E156 0B00 00F0        A3 AND LIT = B          % ISOLATE "M" FIELD
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0AA9   4809 0C52 0000 00FC            B EQL 0                                                   03658000 D
0AAA   6B09 00C0 0030 00F0            IF TRUE THEN SET LC1; SKIP ELSE STEP                      03659000 D
0AAB   238C 0000 0C30 0060            CONTENTSRM - 1 = CPCR   * (R(M)) INTO B                   03660000 D
0AAC   4809 E000 A000 00F0            A3 R = A2               * "Y" INTO A2                     03661000 D
0AAD   0000 0000 0000 0020            15 = SAR                                                  03662000 D
0AAE   4809 CC40 2000 00F0            A2 + B = A2             * Y INTO A2                       03663000 D
0AAF   4809 E000 8B00 00FC            A3 R = B                                                  03664000 D
0AB0   8000 0000 0000 000C            4 = SAR                                                   03665000 D
0AB1   4809 2C56 0B30 00F0            LIT AND B = B           * ISOLATE "A" FIELD               03666000 D
0AB2   00F0 0000 0000 00E0            15 = LIT                                                  03667000 D
0AB3   51CC 0000 0000 0060            REGSTACK - 1 = CPCR                                       03668000 D
0AB4   2F30 C0C0 0030 0060            EINPUT - 1 = CPCR       * (R(A)) INTO B                   03669000 D
0AB5   4809 0F41 0020 00F0            BMAR L = BR1            * SAVE ADDR OF R(A) IN BR1        03670000 D
0AB6   0000 0000 0C30 C030            COMP 8 = SAR                                              03671000 D
0AB7   4809 0C41 1030 00F0            B L = A3                * (R(A)) INTO MS A3               03672000 D
0AB8   0010 0000 0000 00A0            16 = SAR; 1 = LIT                                         03673000 D
0AB9   4809 2F5C 001C 00F0            LIT OR BMAR = MAR2      * R(A+1)                          03674000 D
0ABA   2F3C 0000 0000 0060            EINPUT - 1 = CPCR       * (R(A+1)) INTO D                 03675000 D
0ABB   4809 EC5C 0B30 00F0            A3 OR B = B             * D = (R(A))/(R(A+1))             03676000 D
0ABC   4809 C000 000C 80F0            A2 = SAR                * Y (C-5) INTO SAR                03677000 D
0ABD   49C9 CC40 AB00 00F0            B R = B, A2; SET LC1    * PERFORM RIGHT SHIFT OF Y (C-5)  03678000 D
0ABE   20D0 0000 0030 0060            SETCCA - 1 = CPCR       * SET THE CONDITION BITS          03679000 D
0ABF   4809 C000 8C30 00F0            A2 R = MIR              * SHIFTED (R(A)) INTO MIR         03680000 D
0AC0   0000 0000 0000 0020            16 = SAR                                                  03681000 D
0AC1   4809 00C0 0000 20F0            ASR                     * REFERENCE BR1                   03682000 D
0AC2   48C9 0F40 801C 00F0            BMAR R = MAR2           * ADDR OF R(A)                    03683000 D
0AC3   0000 0000 0C00 C010            8 = SAR                                                   03684000 D
0AC4   2F50 0000 0030 0060            EOUTPUT - 1 = CPCR      * WRITE NEW (R(A))                03685000 D
0AC5   4809 2F5C 001C 00F0            LIT OR BMAR = MAR2      * R(A+1)                          03686000 D
0AC6   001C 0000 0030 00A0            1 = LIT; 16 = SAR                                         03687000 D
0AC7   4809 C001 2000 00FC            A2 L = A2               * ISOLATE (R(A+1))                03688000 D
0AC8   4809 C0C0 8C30 0CF0            A2 R = MIR                                                03689000 D
0AC9   2F50 0000 0000 0060            EOUTPUT - 1 = CPCR        * WRITE NEW (R(A+1))            03690000 D
0ACA   66E0 0000 0000 0040            OPCODE - 1 = MPCR                                         03691000 D
                                                              *                                 03692000 D
                                                              *                                 03693000 D
                             OP123:                           * STORE DOUBLE                    03694000 D
                                                              * STORE (R(A)) INTO Y, (R(A+1)) INTO Y+1 03695000 D
0ACB   5700 0000 0030 0C60            RXMFIELD - 1 = CPCR     * Y INTO B                        03696000 D
0ACC   4809 0C40 0030 00F0            B = MIR                 * TRANSFER Y TO MIR               03697000 D
0ACD   4809 E000 9000 00F0            A3 R = A3                                                 03698000 D
0ACE   8000 0000 0000 0000            4 = SAR                                                   03699000 D
0ACF   4809 E156 0B30 C0F0            A3 AND LIT = B          * ISOLATE "A" FIELD               03700000 D
0AD0   00FC 0000 0030 00EC            15 = LIT                                                  03701000 D
0AD1   51CC 0000 0000 0060            REGSTACK - 1 = CPCR     * ADDR OF R(A) INTO MAR2          03702000 D
0AD2   2F30 0000 0030 0060            EINPUT - 1 = CPCR       * (R(A)) INTO E                   03703000 D
0AD3   4809 0C40 0030 C0F0            B = MIR,EMI             * (R(A)) INTO MIR, Y INTO E       03704000 D
0AD4   4809 0F40 1030 C0F0            BMAR = A3               * SAVE ADDR OF R(A) IN A3         03705000 D
0AD5   4809 0C41 0010 C0F0            B L = BR2                                                 03706000 D
0AD6   0000 0000 0030 0030            COMP 8 = SAR                                              03707000 D
0AD7   61E0 0000 0000 0060            EMULOUT - 1 = CPCR      * WRITE (R(A)) INTO Y             03708000 D
0AD8   4809 2F5C 2030 C0F0            LIT OR BMAR = A2        * Y + 1 ADDRESS                   03709000 D
0AD9   0010 C000 0000 00E0            1 = LIT                                                   03710000 D
0ADA   4809 E0DC 001C C0F0            A3 OR 1 = MAR2          * ADDR OF R(A+1)                  03711000 D
0ADB   2F30 0000 000C 0060            EINPUT - 1 = CPCR       * (R(A+1)) INTO B                 03712000 D
0ADC   4809 0C40 0030 C0F0            B = MIR                                                   03713000 D
0ADD   4809 C001 001C 00F0            A2 L = BR2              * ADDR OF Y + 1                   03714000 D
0ADE   00CC C0C0 0000 003C            COMP 8 = SAR                                              03715000 D
0ADF   61E0 0000 0000 0060            EMULOUT - 1 = CPCR                                        03716000 D
0AE0   66E0 0000 0000 0040            OPCODE - 1 = MPCR                                         03717000 D
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                                                                  *
                                                                  *
                        OPCODE13:                                 * SHIFT
0AE1  5F90 0000 0000 0060            XFCODE - 1 = CPCR            * "F" INTO A2
0AE2  4809 C640 0040 C0F0            A2 + AMPCR = AMPCR
0AE3  14FC 0000 0000 C0C0            OP13F - 1 = AMPCR
0AE4  4809 0000 0000 00FC            STEP
0AE5  4824 0000 0000 00F0            EXEC
                                                                  *
                                                                  *
0AE6  1500 0000 0000 0040   OP13F:   OP130 - 1 = MPCR
0AE7  3000 0000 0000 0040            FAULT - 1 = MPCR
0AE8  1510 0000 0000 0040            OP132 - 1 = MPCR
0AE9  1520 0000 0000 0040            OP133 - 1 = MPCR
                                                                  *
                                                                  *
                        OP130:                                    * RR TYPE ALG RIGHT DOUBLE SHIFT
                                                                  * SHIFT (R(A),R(A+1)) RIGHT R(M) (0-5)
                                                                  * SIGN FILL AND SET CC
0AEA  4809 0C40 8B00 00F0            B R = B
0AEB  80FC 0000 0000 0080            4 = SAR; 15 = LIT
0AEC  4809 2C56 0B00 C0F0            LIT AND B = B                * ISOLATE "A" FIELD
0AED  51CC 0000 0000 0060            REGSTACK - 1 = CPCR          * ADDR OF R(A) INTO MAR2
0AEE  2F30 0000 0000 006C            EINPUT - 1 = CPCR            * (R(A)) INTO B
0AEF  4809 0C41 2000 00F0            B L = A2                     * TEMP STORAGE OF (R(A))
0AF0  0010 0000 0000 C0A0            COMP 16 = SAR; 1 = LIT
0AF1  4809 0F41 0020 00F0            BMAR L = BR1                 * TEMP STORAGE OF R(A)
0AF2  0000 0000 0000 0030            COMP 8 = SAR
0AF3  4809 2F5C 001C 00FC            LIT OR BMAR = MAR2           * R(A+1) INTO MAR2
0AF4  2F30 0000 0000 C060            EINPUT - 1 = CPCR            * (R(A+1)) INTO B
0AF5  4809 CC5C 2000 00F0            A2 OR B = A2                 * A2 = (R(A))/(R(A+1))
0AF6  4809 C000 0000 C0FC            A2
0AF7  4A49 0000 0000 00F0            IF MST THEN SET LC2
0AF8  4809 E156 0B00 00F0            A3 AND LIT = B               * ISOLATE "M"
0AF9  00F0 0000 0000 00E0            15 = LIT
0AFA  51CC 0000 0000 C060            REGSTACK - 1 = CPCR
0AFB  2F30 0000 0000 006C            EINPUT - 1 = CPCR            * (R(M)) INTO B
0AFC  4809 0C40 0000 80F0            B = SAR                      * (R(M)) (0-5) INTO SAR
0AFD  49C9 C000 AB00 00F0            A2 R = A2,B; SET LC1         * A2 HAS RIGHT SHIFTED (R(A))/(R(A+1))
0AFE  20DC 0000 0000 C060            SETCCA - 1 = CPCR            * SET THE CONDITION BITS
0AFF  3C19 0013 0800 00F0            IF LC2 THEN B111 L = B; SKIP
0B00  4809 0000 0800 C0F0            0 = B
0B01  4809 CC5C 2000 20F0            A2 OR B = A2; ASR
0B02  4809 0F40 801C 00F0            BMAR R = MAR2                * ADDR OF R(A) INTO MAR2
0B03  0000 C000 0000 0010            8 = SAR
0B04  4809 C000 8030 C0F0            A2 R = MIR                   * (R(A)) INTO MIR
0B05  0000 0000 0000 C020            16 = SAR
0B06  2F50 0000 0000 0060            EOUTPUT - 1 = CPCR           * WRITE OUT SHIFTED (R(A))
0B07  4809 C001 2000 00F0            A2 L = A2
0B08  0010 0000 0000 00AC            COMP 16 = SAR; 1 = LIT
0B09  4809 C0C0 8B90 00FC            A2 R = MIR, B                * SHIFTED (R(A+1)) INTO MIR
0B0A  4809 2F5C 001C 00F0            LIT OR BMAR = MAR2           * R(A+1)
0B0B  2F50 0000 0000 006C            EOUTPUT - 1 = CPCR
0B0C  66E0 0000 0000 0040            OPCODE - 1 = MPCR
                                                                  *
                                                                  *
                        OP132:                                    * PK TYPE ALG RIGHT DOUBLE SHIFT
                                                                  * SHIFT (R(A),R(A+1)) RIGHT Y(0-5)
                                                                  * SIGN FILL AND SET CC
0B0D  4809 2C56 0800 00F0            LIT AND B = B
```

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0B0E   00F0 0000 0000 C0EC         15 = LIT                                                    03778000 D
0B0F   4809 0C52 0000 00F0         B EQL 0                  % CHECK "M" FOR 0                  03779000 D
0B10   6819 0000 0C00 00F0         IF TRUE THEN SKIP;                                          03780000 D
0B11   2380 0000 0000 006C         CONTENTSRM - 1 = CPCR    % (R(M)) INTO B                    03781000 D
0B12   4809 0C41 0B00 00F0         B L = B                                                     03782000 D
0B13   0000 0000 0000 0020         16 = SAR                                                    03783000 D
0B14   4809 EC5C 1000 00F0         A3 OR B = A3             % A3 = (R(M))/INSTRUCTION          03784000 D
0B15   6330 0000 0000 0060         IFETCH - 1 = CPCR        % "Y" INTO B                       03785000 D
0B16   4809 E0C0 AC00 00F0         A3 R = A2                % (R(M)) INTO A2                   03786000 D
0B17   0000 0000 0000 C020         16 = SAR                                                    03787000 D
0B18   4809 CC40 2000 C0F0         A2 + B = A2              % Y INTO A2                        03788000 D
0B19   4809 E0C0 8B00 00F0         A3 R = B                 % ISOLATE "A"                      03789000 D
0B1A   80FC C000 0C0C 0080         4 = SAR; 15 = LIT                                           03790000 D
0B1B   4809 2C56 0B00 00F0         LIT AND B = B            % "A" INTO B                       03791000 D
0B1C   51C0 0000 0C0C C060         REGSTACK - 1 = CPCR      % ADDR OF R(A) INTO MAR2           03792000 D
0B1D   2F30 0000 0000 006C         EINPUT - 1 = CPCR        % (R(A)) INTO B                    03793000 D
0B1E   4809 CC41 1000 00F0         B L = A3                 % TEMP STORAGE OF (R(A))           03794000 D
0B1F   0000 0000 0000 0020         COMP 16 = SAR                                               03795000 D
0B20   4809 CF41 0C20 C0F0         BMAR L = BR1             % SAVE ADDR OF R(A) IN BR1         03796000 D
0B21   001C 0000 C000 00B0         COMP 8 = SAR ; 1 = LIT                                      03797000 D
0B22   4809 2F5C 001C C0F0         LIT OR BMAR = MAR2       % R(A+1)                           03798000 D
0B23   2F30 0000 0000 0060         EINPUT - 1 = CPCR        % (R(A+1)) INTO B                  03799000 D
0B24   4809 EC5C 1000 00F0         A3 OR B = A3             % A3 = (R(A)/(R(A+1))              03800000 D
0B25   4809 E0C0 0000 00F0         A3                                                          03801000 D
0B26   4A49 0000 0000 00FC         IF MST THEN SET LC2                                         03802000 D
0B27   4809 C0C0 000C 80FC         A2 = SAR                 % Y(0-5) INTO SAR                  03803000 D
0B28   49C9 E000 9B0C 00F0         A3 R = A3,B; SET LC1     % SHIFT (R(A))/(R(A+1))            03804000 D
0B29   2000 0000 0000 0060         SETCCA - 1 = CPCR        % SET THE CONDITION BITS           03805000 D
0B2A   3C19 0019 0B0C C0F0         IF LC2 THEN B111 L = B; SKIP                                03806000 D
0B2B   4009 0000 CB00 00F0         0 = B                                                       03807000 D
0B2C   4809 EC5C 1000 C0F0         A3 OR B = A3             % PERFORM SIGN FILL                03808000 D
0B2D   4809 0000 C00C 20F0         ASR                      % REFERENCE BR1                    03809000 D
0B2E   4809 CF40 801C 00F0         BMAR R = MAR2            % ADDR OF R(A) INTO MAR2           03810000 D
0B2F   0000 0000 0000 C01C         8 = SAR                                                     03811000 D
0B30   48C9 E0C0 8030 00F0         A3 R = MIR                                                  03812000 D
0B31   0000 0000 0000 002C         16 = SAR                                                    03813000 D
0B32   2F50 0000 0000 C060         EOUTPUT - 1 = CPCR       % WRITE OUT NEW (R(A))             03814000 D
0B33   0010 0000 0000 00A0         COMP 16 = SAR; 1 = LIT                                      03815000 D
0B34   4809 2F5C 001C 00FC         LIT OR BMAR = MAR2       % R(A+1)                           03816000 D
0B35   4809 E001 1000 00F0         A3 L = A3                                                   03817000 D
0B36   4809 EC00 8B30 00F0         A3 R = MIR, B            % NEW (R(A+1))                     03818000 D
0B37   2F50 0000 0000 0060         EOUTPUT - 1 = CPCR                                          03819000 D
0B38   66E0 0000 0000 C040         OPCODE - 1 = MPCR                                           03820000 D
                                                            %                                  03821000 D
                                                            %                                  03822000 D
                           OP133:                           % RX TYPE STORE MULTIPLE           03823000 D
                                                            % (R(A),...R(M)) INTO Y,...Y+M-A+1 03824000 D
0B39   6330 0000 0000 0060         IFETCH - 1 = CPCR        % Y INTO B                         03825000 D
0B3A   4809 0C41 C020 C0FC         B L = BR1                % SAVE Y IN BR1                    03826000 D
0B3B   0000 0000 0C00 003C         COMP 8 = SAR                                                03827000 D
0B3C   4809 E156 2000 00FC         A3 AND LIT = A2          % "M" INTO A2                      03828000 D
0B3D   80FC 0000 0000 0080         4 = SAR; 15 = LIT                                           03829000 D
0B3E   4809 E000 9C00 C0F0         A3 R = A3                                                   03830000 D
0B3F   4809 E155 0B90 00F0         A3 AND LIT = B, MIR      % "A" INTO B, MIR                  03831000 D
0B40   4809 CC5E 0B0C 00F0         A2 - B = B               % CHECK IF "M" < "A"               03832000 D
0B41   4419 0C46 0B00 C0F0         IF NOT MST THEN B + 1 = B; SKIP                             03833000 D
0B42   4809 2C40 0B00 C0F0         LIT + B = B              % CALCULATE 16 + (M-A) + 1         03834000 D
0B43   0110 0000 C000 00E0         17 = LIT                                                    03835000 D
0B44   4809 0C5F 1000 C0F0         -B L = A3, BMI           % A3 IS NEG CTR, B HOLDS "A"       03836000 D
0B45   000C C0C0 0000 0020         COMP 16 = SAR                                               03837000 D
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0B46  51C0 0000 0000 0060   STMU:     REGSTACK - 1 = CPCR      % ADDR OF R(A) INTO MAR2                 03838000 D
0B47  2F3C 0000 0000 C060             EINPUT - 1 = CPCR        % (R(A)) INTO B                          03839C00 D
0B48  4809 0F46 001C C0F0             BMAR + 1 = MAR2          % INCREMENT R(A)                         03840C00 D
0B49  4809 E0C0 9000 00F0             A3 R = A3                % CLEAR LHW OF A3                        03841000 D
0B4A  0000 0000 C000 C020             16 = SAR                                                          03842C00 D
0B4B  4809 E0C1 1C00 00F0             A3 L = A3                                                         03843C00 D
0B4C  4809 EF5C 1000 00F0             A3 OR BMAR = A3          % A3 = -CTR/R(A+X)                       03844C00 D
0B4D  4809 0C40 0030 20FC             D = MIR; ASR                                                      03845C00 D
0B4E  4809 0F43 0010 00F0             BMAR = BR2               % LOAD BR2 WITH Y                        03846C00 D
0B4F  61EC 0000 0070 0060             EMULOUT - 1 = CPCR       % WRITE OUT NEW Y VALUE                  03847000 D
0B50  4809 0F46 001C 00F0             BMAR + 1 = MAR2          % NEXT Y ADDRESS                         03848C00 D
0B51  4809 0F41 0C20 C0FC             BMAR L = BR1             % SAVE NEXT Y IN BR1                     03849C00 D
0B52  000C 0000 0C00 0030             COMP 8 = SAR                                                      03850C00 D
0B53  4809 00C1 0B0C 00F0             1 L = B                  % 1 IN BIT 16 OF B                       03851000 D
0B54  0000 0000 000C C020             COMP 16 = SAR                                                     03852C00 D
0B55  4809 EC40 1600 00F0             A3 + B = A3              % INCREMENT NEGATIVE COUNTER             03853C00 D
0B56  4809 E156 0BCC 00F0             A3 AND LIT = B           % ISOLATE ADDR OF NEXT R(A+X)            03854C00 D
0B57  01F0 0000 0000 00E0             31 = LIT                                                          03855C00 D
0B58  4809 E0C0 0000 00F0             A3                       % A3 TO THE ADDER                        03856C00 D
0B59  480B 0000 0000 C0FC             IF MST THEN STEP ELSE SKIP  % IF CTR NEG, FETCH NEXT R(A+X)       03857C00 D
0B5A  B45C 0000 0000 004C             STMU - 1 = MPCR          % RETURN TO TOP OF LOOP                  03858C00 D
0B5B  56EC 0000 000C C040             OPCODE - 1 = MPCR                                                 03859C00 D
                                                               %                                        03860C00 D
                                                               %                                        03861C00 D
                            OPCODE14:                          % ALGEBRAIC LEFT SHIFT                   03862C00 D
0B5C  5F9C 0000 0C0C 0060             XFCODE - 1 = CPCR        % "F" INTO A2                            03863C00 D
0B5D  4809 C640 004C C0FC             A2 + AMPCR = AMPCR                                                03864C00 D
0B5E  153C C0C0 0000 00C0             OP14F - 1 = AMPCR                                                 03865C00 D
0B5F  4809 0000 000C C0F0             STEP                                                              03866C00 D
0B60  4824 0000 000C 00F0             EXEC                                                              03867000 D
                                                               %                                        03868C00 D
                                                               %                                        03869C00 D
0B61  1540 0C00 000C 0040   OP14F:    OP140 - 1 = MPCR                                                  03870C0C D
0B62  3000 0CC0 000C 004C             FAULT - 1 = MPCR                                                  03871C00 D
0B63  1550 C0C0 0C00 0040             OP142 - 1 = MPCR                                                  03872000 D
0B64  156C 0C00 0000 C04C             OP143 - 1 = MPCR                                                  03873C00 D
                                                               %                                        03874C00 D
                                                               %                                        03875C00 D
                            OP140:                             % RR TYPE ALG LEFT SHIFT (REGISTER)      03876C00 D
                                                               % SHIFT (R(A))  LEFT (R(M)) (0-5) PLACES 03877C00 D
                                                               % ZERO FILL, SET CC AND SET OVERFLOW BIT 03878C00 D
0B65  2380 0000 0000 0060             CONTENTSRM - 1 = CPCR    % (R(M)) INTO B                          03879C00 D
0B66  4809 0C40 0030 C0F0             B = MIR                  % TEMP STORAGE                           03880C00 D
0B67  4809 E0C0 0BCC 00F0             A3 = B                   % PUT INSTR BACK INTO B                  03881C00 D
0B68  2280 0CC0 0C0C 0060             CONTENTSRA - 1 = CPCR    % (R(A)) INTO B                          03882C00 D
0B69  4809 0C40 2000 00F0             0 = A2, BMI              % (R(A)) INTO A2, (R(M)) INTO B          03883000 D
0B6A  4809 2C56 0B0C 00F0             LIT AND B = B            % MASK BITS 0-5                          03884C0C D
0B6B  03FC 0000 0C00 C0E0             63 = LIT                                                          03885C00 D
0B6C  4809 2C59 000C C0FC             LIT LEO B                % CHECK FOR SHIFT >= 16                  03886C00 D
0B6D  010C 0000 0C0C CCE0             16 = LIT                                                          03887C0C D
0B6E  7819 0C00 C000 00F0             IF FALSE THEN SKIP                                                03888C00 D
0B6F  157C C0C0 0C00 0040             C140 - 1 = MPCR          % SHIFT >= 16                            03889C00 D
0B70  4809 0C5E 000C 80FC             -B = SAR                                                          03890C00 D
0B71  4809 C0C1 2C00 C0F0             A2 L = A2                % PERFORM LEFT SHIFT                     03891C00 D
0B72  4809 C0C3 9C00 00FC             A2 R = A3                % PUT DIGITS SHIFTED OUT IN A3           03892000 D
0B73  000C 0C00 0000 0020             16 = SAR                                                          03893C00 D
0B74  4809 C001 200C C0FC             A2 L = A2                % CLEAR UHW A2                           03894C00 D
0B75  4809 C0C0 8B30 C0FC             A2 R = MIR, B            % SHIFTED (R(A)) INTO MIR                03895C00 D
0B76  4809 E0C2 0000 00FC             NOT A3                                                            03896000 D
0B77  63C9 0000 0C00 C0F0             IF NOT ABT THEN SET LC1  % FLAG FOR SETTING OV BIT                03897C00 D
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0B78  5020 0000 0000 0060           OVBIT - 1 = CPCR        % SET OV BIT ACCORDINGLY                  03898000 D
0B79  2000 0000 0000 0060           SETCCA - 1 = CPCR       % SET THE CONDITION BITS                  03899000 D
0B7A  2F50 0000 0000 0060           EOUTPUT - 1 = CPCR                                                03900000 D
0B7B  66E0 0000 0000 0040           OPCODE - 1 = MPCR                                                 03901000 D
0B7C  4809 C012 0000 00F0  C140:    A2 EQL 0                % CHECK FOR 0 IN R(A)                     03902000 D
0B7D  63C9 0000 0000 00F0           IF FALSE THEN SET LC1                                             03903000 D
0B7E  5020 0000 0000 0060           OVBIT - 1 = CPCR        % SET OV BIT ACCORDINGLY                  03904000 D
0B7F  4809 0000 0C30 00F0           0 = MIR                 % SHIFT >= 16, -> 0  INTO R(A)            03905000 D
0B80  21BC 0000 0000 0060           SETOG - 1 = CPCR                                                  03906000 D
0B81  2F50 0000 0000 0060           EOUTPUT - 1 = CPCR                                                03907000 D
0B82  66E0 0000 0000 0040           OPCODE - 1 = MPCR                                                 03908000 D
                                                            %                                         03909000 D
                                                            %                                         03910000 D
                           OP142:                           % RR TYPE ALG LEFT SINGLE SHIFT           03911000 D
                                                            % SHIFT (R(A)) LEFT Y (0-5) PLACES        03912000 D
                                                            % ZERO FILL AND SET CC, SET OVERFLOW BIT  03913000 D
0B83  6330 0000 0C30 0060           IFETCH - 1 = CPCR       % "Y" INTO B                              03914000 D
0B84  4809 0C40 0030 00FC           B = MIR                 % "Y" INTO MIR                            03915000 D
0B85  4809 E156 0B00 00F0           A3 AND LIT = B          % ISOLATE "M"                             03916000 D
0B86  00FC 0000 0000 00E0           15 = LIT                                                          03917000 D
0B87  4809 0C52 0000 00F0           0 EQL B                 % CHECK FOR 0 , "M" FIELD                 03918000 D
0B88  6819 0000 0000 C0F0           IF TRUE THEN SKIP                                                 03919000 D
0B89  2380 0000 0000 006C           CONTENTSRM - 1 = CPCR   % (R(M)) INTO B                           03920000 D
0B8A  4809 0C40 2030 00F0           B = A2, BMI             % (R(M) INTO A2, "Y" INTO B               03921000 D
0B8B  4809 0C43 0030 00F0           A2 + B = MIR            % Y INTO MIR                              03922000 D
0B8C  4809 EC00 9000 00F0           A3 R = A3                                                         03923000 D
0B8D  80FC 0000 0C30 008C           4 = SAR; 15 = LIT                                                 03924000 D
0B8E  48C9 E156 0B00 00F0           A3 AND LIT = B          % ISOLATE "A"                             03925000 D
0B8F  51C0 0000 0000 0060           REGSTACK - 1 = CPCR     % R(A) INTO MAR2                          03926000 D
0B90  2F30 C0C0 0000 0060           EINPUT - 1 = CPCR       % (R(A)) INTO B                           03927000 D
0B91  48C9 0C40 2030 C0F0           B = A2, BMI             % (R(A)) INTO A2, Y INTO 0                03928000 D
0B92  4809 2C56 CB00 00F0           LIT AND B = B           % ISOLATE SHIFT AMOUNT                    03929000 D
0B93  03F0 0000 0000 00E0           63 = LIT                                                          03930000 D
0B94  4809 2C59 0000 00FC           LIT LEQ B               % IS SHIFT AMOUNT > 16 ?                  03931000 D
0B95  0100 0000 0000 00E0           15 = LIT                                                          03932000 D
0B96  7819 0000 0600 00F0           IF FALSE THEN SKIP                                                03933000 D
0B97  158C 0000 0000 0040           C142 - 1 = MPCR         % SHIFT > 16                              03934000 D
0B98  4809 0C55 0000 80F0           -B = SAR                                                          03935000 D
0B99  4809 C001 2000 00FC           A2 L = A2               % PERFORM REQUIRED LEFT SHIFT             03936000 D
0B9A  4809 C000 9000 00F0           A2 R = A3               % PUT LEFT SHIFTED BITS INTO A3           03937000 D
0B9B  0C00 0000 0000 C020           16 = SAR                                                          03938000 D
0B9C  4809 C001 2030 00F0           A2 L = A2               % CLEAR UHW OF A2                         03939000 D
0B9D  4809 C0C0 8B30 00F0           A2 R = MIR, B           % NEW (R(A)) INTO MIR, B                  03940000 D
0B9E  4809 E002 0C00 00FC           NOT A3                                                            03941000 D
0B9F  63C9 00C0 0000 C0FC           IF NOT ABT THEN SET LC1                                           03942000 D
0BA0  5020 00C0 C03C 0060           OVBIT - 1 = CPCR        % SET THE OV BIT ACCORDINGLY              03943000 D
0BA1  2000 00C0 0000 0060           SETCCA - 1 = CPCR       % SET THE CC                              03944000 D
0BA2  2F50 0000 0000 0060           EOUTPUT - 1 = CPCR      % WRITE OUT NEW R(A)                      03945000 D
0BA3  66E0 0000 C00C 0040           OPCODE - 1 = MPCR                                                 03946000 D
0BA4  4809 C012 0C00 00F0  C142:    A2 EQL 0                % CHECK FOR A ZERO (R(A))                 03947000 D
0BA5  63C9 0000 C000 00F0           IF FALSE THEN SET LC1                                             03948000 D
0BA6  502C C000 0000 006C           OVBIT - 1 = CPCR        % SET THE OV BIT                          03949000 D
0BA7  4809 0000 0C30 00FC           C = MIR                 % PREPARE TO WRITE 0 INTO R(A)            03950000 D
0BA8  21B0 00C0 C030 0060           SETOC - 1 = CPCR                                                  03951000 D
0BA9  2F5C 0000 C030 0060           EOUTPUT - 1 = CPCR                                                03952000 D
0BAA  66E0 0000 0C00 0040           OPCODE - 1 = MPCR                                                 03953000 D
                                                            %                                         03954000 D
                                                            %                                         03955000 D
                           OP143:                           % RX TYPE BYTE STORE INDEX                03956000 D
                                                            % (R(A)) BITS 0-7 INTO Y BYTE             03957000 D
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0BAB  4849 0000 0000 00F0              SET LC2                    % BYTE INSTRUCTION FLAG                  03959000 D
0BAC  5700 0C00 0000 0060              RXMFIELD - 1 = CPCR        % Y ADDR INTO E                          03960000 D
0BAD  4809 0C41 0020 00F0              D L = BR1                  % TEMP STORAGE OF Y ADDR                 03961000 D
0BAE  0000 0000 000C 0030              COMP 8 = SAR                                                        03962000 D
0BAF  4809 E000 0600 00F0              A3 = B                                                              03963000 D
0BB0  22B0 0000 0070 0060              CONTENTSRA - 1 = CPCR      % (R(A)) INTO B                          03964000 D
0BB1  4809 2C55 0030 00F0              LIT AND B = MIR            % (R(A)) BITS 0-7 INTO MIR               03965000 D
0BB2  0FF0 0000 0000 00E0              255 = LIT                                                           03966000 D
0BB3  2380 0000 0000 0060              CONTENTSRM - 1 = CPCR      % (R(M)) INTO B                          03967000 D
0BB4  4809 0C45 0B00 00F0              D + 1 = B                                                           03968000 D
0BB5  4809 0C40 0030 00F0              B = MIR, BMI               % (R(M)) + 1 INTO MIR, (R(A)) INTO B     03969000 D
0BB6  2F50 0000 0000 0060              EOUTPUT - 1 = CPCR         % (R(M)) + 1 INTO R(M)                   03970000 D
0BB7  4809 0C40 1000 00FC              B = A3                     % MOVE (R(A)) BITS 0-7 TO LS BYTE OF A3  03971000 D
0BB8  4809 C000 0000 20F0              ASR                        % REFERENCE BR1                          03972000 D
0BB9  4809 0F40 0010 00FC              BMAR = DR2                 % Y ADDR INTO BR2                        03973000 D
0BBA  60EC 0000 0070 0060              EMULIN - 1 = CPCR          % (Y) INTO B                             03974000 D
0BBB  380B 0000 0000 00F0              IF LC2 THEN STEP ELSE SKIP % IF LC2, PUT BYTE INTO LS BYTE          03975000 D
0BBC  159C 0000 0000 0060              LS143 - 1 = CPCR                                                    03976000 D
0BBD  4809 0C41 0D00 40F0              B L = B, CSAR                                                       03977000 D
0BBE  0000 0000 0000 0010              COMP 24 = SAR                                                       03978000 D
0BBF  4809 0C40 8B00 00F0              B R = B                                                             03979000 D
0BC0  4809 E0C1 1000 00F0              A3 L = A3                                                           03980000 D
0BC1  0000 0000 0000 0030              COMP 8 = SAR                                                        03981000 D
0BC2  4809 EC5C C030 00F0              A3 OR B = MIR                                                       03982000 D
0BC3  4809 0F41 0010 00F0              EMAR L = BR2               % SET UP BR2 FOR EMULOUT                 03983000 D
0BC4  0000 0000 0000 0030              COMP 8 = SAR                                                        03984000 D
0BC5  61EC 0000 0000 0060              EMULOUT - 1 = CPCR                                                  03985000 D
0BC6  66E0 0000 0000 0040              OPCODE - 1 = MPCR                                                   03986000 D
0BC7  4809 0C40 8B00 40F0  LS143:      B R = B, CSAR              % CLEAR LS BYTE OF B                     03987000 D
0BC8  4809 0C41 0B00 00FC              B L = B                                                             03988000 D
0BC9  4809 EC5C 0030 00F0              A3 OR B = MIR                                                       03989000 D
0BCA  4809 0F41 0010 00F0              BMAR L = BR2               % SET UP FOR EMULOUT                     03990000 D
0BCB  61EC 0000 0000 0060              EMULOUT - 1 = CPCR                                                  03991000 D
0BCC  66E0 0000 0000 0040              OPCODE - 1 = MPCR                                                   03992000 D
                                                                  %                                        03993000 D
                                                                  %                                        03994000 D
0BCD  5F90 0000 0000 0060  OPCODE15:   XFCODE - 1 = CPCR          % "F" INTO A2                            03995000 D
0BCE  4809 C640 0090 00F0              A2 + AMPCR = AMPCR                                                  03996000 D
0BCF  15AC 0000 0000 0CC0              OP15F - 1 = AMPCR                                                   03997000 D
0BD0  4809 0000 0000 00FC              STEP                                                                03998000 D
0BD1  4824 0000 0000 00FC              EXEC                                                                03999000 D
                                                                  %                                        04000000 D
0BD2  15BC 0000 0000 0040  OP15F:      OP150 - 1 = MPCR                                                    04001000 D
0BD3  15C0 0000 0000 0040              OP151 - 1 = MPCR                                                    04002000 D
0BD4  15DC 0000 0000 0040              OP152 - 1 = MPCR                                                    04003000 D
0BD5  15E0 0000 0000 0040              OP153 - 1 = MPCR                                                    04004000 D
                                                                  %                                        04005000 D
                                                                  %                                        04006000 D
                           OP150:                                 % RR TYPE CIRCULAR SINGLE SHIFT          04007000 D
                                                                  % SHIFT (R(A)) LEFT CIRCULARLY (R(M))    04008000 D
                                                                  % BITS 0-5 AND SET CC                    04009000 D
0BD6  2380 0000 0000 0060              CONTENTSRM - 1 = CPCR      % (R(M)) INTO B                          04010000 D
0BD7  4809 0C40 0030 00F0              B = MIR                    % (R(M)) INTO MIR                        04011000 D
0BD8  4809 E000 0B00 00F0              A3 = B                                                              04012000 D
0BD9  22B0 0000 0000 0060              CONTENTSRA - 1 = CPCR      % (R(A)) INTO B                          04013000 D
0BDA  4809 0C40 2000 00F0              E = A2                                                              04014000 D
0BDB  4809 C001 2000 00F0              A2 L = A2                                                           04015000 D
0BDC  03F0 0000 0000 00A0              COMP 16 = SAR; 63 = LIT                                             04016000 D
0BDD  4809 CC5C 2000 00F0              A2 OR B = A2, BMI          % A2 = (R(A))/(R(A)), (R(M)) INTO E      04017000 D
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0BDF  4812 0000 0000 00F0                 SAVE                                                      04019000 D
0BE0  4809 E15E 0000 00F0                 A3 GEQ LIT                                                04020000 D
0BE1  010C 0000 0030 00E0                 16 = LIT                                                  04021000 D
0BE2  7C29 E15E 1000 00F0                 IF TRUE THEN A3+ NOT LIT + 1 = A3; JUMP                   04022000 D
0BE3  4809 EC00 0B00 00F0                 A3 = B                                                    04023000 D
0BE4  4809 2C5E 003C 80F0                 LIT - B = SAR                                             04024000 D
0BE5  4809 C001 800C 00F0                 A2 C = B                                                  04025000 D
0BE6  4809 0C41 0B0C 00F0                 B L = B                                                   04026000 D
0BE7  000C 0000 0000 C020                 16 = SAR                                                  04027000 D
0BE8  4809 0C40 8830 00F0                 B R = MIR, B                                              04028000 D
0BE9  2F50 0000 0030 0060                 EOUTPUT - 1 = CPCR                                        04029000 D
0BEA  200C 0000 C0CC C060                 SETCCA - 1 = CPCR      % SET THE CONDITION BITS           04030000 D
0BEB  66E0 0000 0000 0040                 OPCODE - 1 = MPCR                                         04031000 D
                                                                 %                                  04032000 D
                                                                 %                                  04033000 D
                                OP151:                           % RI TYPE 2 STORE AND INDEX BY 1   04034000 D
                                                  % (R(A)) INTO Y*, (R(M)) + 1 INTO R(M)            04035000 D
0BEC  2380 0000 003C 006C                 CONTENTSRM - 1 = CPCR  % (R(M)) INTO B                    04036000 D
0BED  4809 0C41 002C 00F0                 B L = BR1              % Y* INTO BR1                      04037000 D
0BEE  000C 0000 0C0C 0030                 COMP B = SAR                                              04038000 D
0BEF  4809 EC03 0830 00F0                 A3 = B                                                    04039000 D
0BF0  2280 0000 000C C060                 CONTENTSRA - 1 = CPCR  % (R(A)) INTO B                    04040000 D
0BF1  4809 0C40 0C30 20F0                 B = MIR; ASR                                              04041000 D
0BF2  4809 0F43 0010 C0F0                 BMAR = BR2                                                04042000 D
0BF3  61EC 0000 0C0C 006C                 EMULOUT - 1 = CPCR     % (R(A)) INTO Y*                   04043000 D
0BF4  4809 0F46 CC30 00FC                 BMAR + 1 = MIR         % (R(M)) + 1                       04044000 D
0BF5  4809 E156 CB3C 00F0                 A3 AND LIT = B         % ISOLATE "M" FIELD                04045000 D
0BF6  00F0 0000 0030 00E0                 15 = LIT                                                  04046000 D
0BF7  51CC 0000 0030 0060                 REGSTACK - 1 = CPCR    % MAR2 = ADDR OF R(M)              04047000 D
0BF8  2F5C 0003 0C30 CC60                 EOUTPUT - 1 = CPCR     % (R(A)) + 1 INTO R(M)             04048000 D
0BF9  66EC 000D 0030 C040                 OPCODE - 1 = MPCR                                         04049000 D
                                                                 %                                  04050000 D
                                                                 %                                  04051000 D
                                OP152:                           % RK TYPE CIRCULAR LEFT SINGLE SHIFT   04052000 D
                                                  % SHIFT (R(A)) Y (C-5) PLACES AND SET CC          04053000 D
0BFA  4809 2C56 083C C0F0                 LIT AND B = B          % ISOLATE "M"                      04054000 D
0BFB  00FC 000D 0030 00E0                 15 = LIT                                                  04055000 D
0BFC  4809 0C52 C03C 00F0                 B EQL 0                                                   04056000 D
0BFD  6819 0000 0C0C C0F0                 IF TRUE THEN SKIP                                         04057000 D
0BFE  238C 0000 0030 0060                 CONTENTSRM - 1 = CPCR  % (R(M)) INTO B                    04058000 D
0BFF  4809 CC41 0830 C0FC                 B L = B                                                   04059000 D
0C00  000C 0000 0C0C C02C                 COMP 16 = SAR                                             04060000 D
0C01  4809 EC5C 1000 C0F0                 A3 OR B = A3           % A3 = (R(M))/INSTRUCTION          04061000 D
0C02  633C 0000 0030 0060                 IFETCH - 1 = CPCR      % Y INTO B                         04062000 D
0C03  4809 EC00 AC0C 0CF0                 A3 R = A2              % (R(M)) INTO A2                   04063000 D
0C04  000C 0000 C03C 0020                 16 = SAR                                                  04064000 D
0C05  4809 CC40 2000 C0FC                 A2 + B = A2            % Y INTO A2                        04065000 D
0C06  4809 C156 0030 00FC                 A2 AND LIT = MIR       % Y(C-5)                           04066000 D
0C07  93FC C000 0C0C 008C                 63 = LIT; 4 = SAR                                         04067000 D
0C08  4809 E003 900C C0F0                 A3 R = A3                                                 04068000 D
0C09  4809 E156 083C 00F0                 A3 AND LIT = B         % ISOLATE "A"                      04069000 D
0C0A  00FC C000 0000 C0EC                 15 = LIT                                                  04070000 D
0C0B  51C0 0000 0C00 006C                 REGSTACK - 1 = CPCR    % ADDR OF R(A) INTO MAR2           04071000 D
0C0C  2F30 000D 0C00 006C                 EINPUT - 1 = CPCR      % (R(A)) INTO E                    04072000 D
0C0D  4809 0C41 100C 00F0                 B L = A3                                                  04073000 D
0C0E  010C 0000 0C00 00A0                 COMP 16 = SAR; 16 = LIT                                   04074000 D
0C0F  4809 EC5C 2000 C0F0                 A3 OR B = A2           % A2 = (R(A))/(R(A))               04075000 D
0C10  4809 0000 C000 C0F0                 BMI                                                       04076000 D
0C11  4809 0C40 1000 00FC                 B = A3                                                    04077000 D
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0C12  4812 0000 0000 00F0             SAVE
0C13  4809 E15E 0C00 00F0             A3 GEO LIT               % CHECK FOR SHIFT > 16                         04079000 D
0C14  7C29 E15E 1000 00F0             IF TRUE THEN A3 + NOT LIT + 1 = A3; JUMP                               04080000 D
0C15  4809 E000 0B00 00FC             A3 = B                                                                  04081000 D
0C16  4809 2C5E 0030 80F0             LIT - B = SAR                                                           04082000 D
0C17  4809 C0C1 8B0C 00F0             A2 C = B                                                                04083000 D
0C18  4809 0C41 0B00 00F0             B L = B                                                                 04084000 D
0C19  000C C000 C000 0020             16 = SAR                                                                04085000 D
0C1A  4809 0C40 8B30 00F0             D R = MIR, B                                                            04086000 D
0C1B  2F50 0C00 0000 0060             EOUTPUT - 1 = CPCR                                                      04087000 D
0C1C  2000 00C0 000C 0060             SETCCA - 1 = CPCR        % SET THE CONDITION BITS                       04088000 D
0C1D  56E0 00C0 0C00 004C             OPCODE - 1 = MPCR                                                       04089000 D
                                                               %                                              04090000 D
                                                               %                                              04091000 D
                           OP153:                              % RX TYPE STORE AND INDEX BY 1                 04092000 D
                                                               % (R(A)) INTO Y, (R(M)) + 1 -> R(M)            04093000 D
0C1E  5700 00C0 0030 0060             RXMFIELD - 1 = CPCR      % ADDR OF Y INTO B                             04094000 D
0C1F  4809 0C41 0020 00F0             B L = DR1                                                               04095000 D
0C20  0000 00C0 0090 0030             COMP 8 = SAR                                                            04096000 D
0C21  48C9 E000 0B00 C0F0             A3 = B                                                                  04097000 D
0C22  2280 00C0 0C00 0060             CONTENTSRA - 1 = CPCR    % (R(A)) INTO B                                04098000 D
0C23  4809 0C40 003C 20F0             B = MIR; ASR                                                            04099000 D
0C24  4809 0F40 001C 00F0             BMAR = BR2               % Y ADDR INTO BR2                              04100000 D
0C25  61EC 0000 0C00 0060             EMULOUT - 1 = CPCR                                                      04101000 D
0C26  2380 0000 003C C060             CONTENTSRM - 1 = CPCR    % (R(M)) INTO B                                04102000 D
0C27  4809 0C46 0030 00F0             B + 1 = MIR                                                             04103000 D
0C28  2F50 0000 0030 0060             EOUTPUT - 1 = CPCR                                                      04104000 D
0C29  66E0 C000 0000 0040             OPCODE - 1 = MPCR                                                       04105000 D
                                                               %                                              04106000 D
                                                               %                                              04107000 D
                           OPCODE16:                                                                          04108000 D
0C2A  5F90 0000 0030 C060             XFCODE - 1 = CPCR        % "F" INTO A2                                  04109000 D
0C2B  4809 C640 0C40 C0F0             A2 + AMPCR = AMPCR                                                      04110000 D
0C2C  15F0 0000 0C30 00CC             OP16F - 1 = AMPCR                                                       04111000 D
0C2D  4809 00C0 0000 C0F0             STEP                                                                    04112000 D
0C2E  4824 0000 0000 00FC             EXEC                                                                    04113000 D
                                                               %                                              04114000 D
0C2F  160C 0000 0030 0040  OP16F:     OP160 - 1 = MPCR                                                        04115000 D
0C30  1610 00C0 000C 0040             OP161 - 1 = MPCR                                                        04116000 D
0C31  1620 0000 0C00 C040             OP162 - 1 = MPCR                                                        04117000 D
0C32  163C 00C0 0030 C040             OP163 - 1 = MPCR                                                        04118000 D
                                                               %                                              04119000 D
                           OP160:                              % RR TYPE ALGEBRAIC LEFT DOUBLE SHIFT          04120000 D
                                                               % SHIFT (R(A),R(A+1)) LEFT (R(M)) (0-5)        04121000 D
                                                               % ZERO FILL AND SET CC, SET OVERFLOW           04122000 D
0C33  4809 0C40 9B0C 00F0             B R = B                                                                 04123000 D
0C34  80FC 00C0 0000 0080             4 = SAR; 15 = LIT                                                       04124000 D
0C35  4809 2C56 0B30 00F0             LIT AND B = B            % ISOLATE THE "A" FIELD                        04125000 D
0C36  51CC 0000 0C00 0060             REGSTACK - 1 = CPCR      % ADDR OF R(A) INTO MAR2                       04126000 D
0C37  2F3C 0000 C000 006C             EINPUT - 1 = CPCR        % (R(A)) INTO B                                04127000 D
0C38  4809 0C41 200C 00F0             B L = A2                 % TEMP STORAGE OF (R(A))                       04128000 D
0C39  001C 00C0 0030 C0AC             COMP 16 = SAR; 1 = LIT                                                  04129000 D
0C3A  4809 0F41 0020 00F0             BMAR L = BR1             % TEMP STORAGE OF R(A)                         04130000 D
0C3B  0000 00C0 0000 0030             COMP 8 = SAR                                                            04131000 D
0C3C  4809 2F5C 001C 00F0             LIT OR BMAR = MAR2       % R(A+1)                                       04132000 D
0C3D  2F3C 00C0 0000 0C6C             EINPUT - 1 = CPCR        % (R(A+1)) INTO B                              04133000 D
0C3E  4809 CC5C 2030 C0FC             A2 OR B = A2             % A2 = (R(A))/(R(A+1))                         04134000 D
0C3F  4809 E156 0B30 00F0             A3 AND LIT = B           % ISOLATE "M" FIELD                            04135000 D
0C40  00F0 00C0 0000 00E0             15 = LIT                                                                04136000 D
0C41  51C0 0000 000C 0060             REGSTACK - 1 = CPCR                                                     04137000 D
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0C43  4809 0C5E 0000 80FC              -B = SAR                                          04139000 D
0C44  4809 C000 9000 C0F0              A2 R = A3              % FOR OVERFLOW TEST        04140000 D
0C45  4809 E002 0000 C0F0              NOT A3                                            04141000 D
0C46  63C9 0000 0000 00F0              IF NOT ABT THEN SET LC1                           04142000 D
0C47  3020 C000 0000 0060              OVBIT - 1 = CPCR       % SET OVERFLOW BIT         04143000 D
0C48  4809 0C5E 0000 80FC              -B = SAR                                          04144000 D
0C49  49C9 C001 2800 00F0              A2 L = A2, B; SET LC1                             04145000 D
0C4A  200C 0000 0000 006C              SETCCA - 1 = CPCR                                 04146000 D
0C4B  4809 C0C0 0000 20F0              ASR                    % REFERENCE BR1            04147000 D
0C4C  4809 0F43 801C 00F0              BMAR R = MAR2                                     04148000 D
0C4D  000C 0000 0000 0010              B = SAR                                           04149000 D
0C4E  48C9 C0C0 8030 00F0              A2 R = MIR                                        04150000 D
0C4F  00C0 0000 0C00 C020              16 = SAR                                          04151000 D
0C50  2F50 00C0 0000 0060              EOUTPUT - 1 = CPCR     % WRITE OUT SHIFTED (R(A)) 04152000 D
0C51  0010 0000 0000 00A0              COMP 16 = SAR; 1 = LIT                            04153000 D
0C52  4809 C001 200C 00F0              A2 L = A2                                         04154000 D
0C53  4809 C00D 8030 C0F0              A2 R = MIR                                        04155000 D
0C54  4809 2F5C 001C 00F0              LIT OR BMAR = MAR2     % R(A+1)                   04156000 D
0C55  2F50 0000 0000 0060              EOUTPUT - 1 = CPCR                                04157000 D
0C56  56EC 0000 0000 C040              OPCODE - 1 = MPCR                                 04158000 D
                                                              %                          04159000 D
                                                              %                          04160000 D
                        OP161:                                % RI TYPE 2 STORE AND INDEX BY 2   04161000 D
                                                              % (R(A),R(A+1)) INTO Y*, Y*+1      04162000 D
                                                              % (R(M)) + 2 INTO R(M)     04163000 D
0C57  238C 0000 C000 0060              CONTENTSRM - 1 = CPCR  % (R(M)) INTO B            04164000 D
0C58  4809 0C41 002C 00F0              B L = BR1              % Y* INTO BR1              04165000 D
0C59  002C C000 0000 C0B0              COMP 8 = SAR; 2 = LIT                             04166000 D
0C5A  4809 2C40 003C 00F0              LIT + B = MIR                                     04167000 D
0C5B  4809 0F41 0C1C 00F0              BMAR L = BR2                                      04168000 D
0C5C  51E0 0000 0000 C06C              EMULOUT - 1 = CPCR     % (R(M)) + 2 INTO R(M)     04169000 D
0C5D  48C9 E000 8800 00F0              A3 R = B                                          04170000 D
0C5E  80FC 0000 0000 0080              15 = LIT; 4 = SAR                                 04171000 D
0C5F  48C9 2C56 0B00 00F0              LIT AND B = B          % ISOLATE "A"              04172000 D
0C60  51C0 0000 0C00 0060              REGSTACK - 1 = CPCR                               04173000 D
0C61  4809 E000 CB00 C0F0              A3 = B                                            04174000 D
0C62  22BC 0C00 000C C060              CONTENTSRA - 1 = CPCR  % (R(A)) INTO E            04175000 D
0C63  4809 0C40 003C C0F0              B = MIR                                           04176000 D
0C64  4809 00C0 0000 20F0              ASR                    % REFERENCE BR1            04177000 D
0C65  4809 0F43 0010 00F0              BMAR = BR2                                        04178000 D
0C66  61EC 00C0 0000 006C              EMULOUT - 1 = CPCR     % (R(A)) INTO Y*           04179000 D
0C67  48C9 0F47 0020 00F0              BMAR + 1 L = BR1       % ADDR OF Y* + 1           04180000 D
0C68  000C 00C0 0000 C030              COMP 8 = SAR                                      04181000 D
0C69  4809 E0C0 8C1C C0F0              A3 R = MAR2            % ADDR OF R(A)             04182000 D
0C6A  001C 0000 0000 C0AC              16 = SAR; 1 = LIT                                 04183000 D
0C6B  4809 2F5C 001C C0F0              LIT OR BMAR = MAR2     % R(A+1)                   04184000 D
0C6C  2F3C C00D 0000 C060              EINPUT - 1 = CPCR      % (R(A+1)) INTO B          04185000 D
0C6D  4809 0C40 003C C0F0              B = MIR                                           04186000 D
0C6E  4809 00C0 0000 20F0              ASR                    % REFERENCE BR1            04187000 D
0C6F  4809 0F43 0010 00F0              BMAR = BR2                                        04188000 D
0C70  61EC 000D C000 C060              EMULOUT - 1 = CPCR     % (R(A+1)) INTO Y* +1      04189000 D
0C71  66E0 0000 CC00 0040              OPCODE - 1 = MPCR                                 04190000 D
                                                              %                          04191000 D
                                                              %                          04192000 D
                        OP162:                                % RK TYPE ALG LEFT DOUBLE SHIFT    04193000 D
                                                              % SHIFT (R(A),R(A+1) LEFT Y (0-5) PLACES 04194000 D
                                                              % ZERO FILL, SET CC AND SET OVERFLOW BIT 04195000 D
0C72  4809 2C56 0B0C 00F0              LIT AND B = B          % ISOLATE "M"              04196000 D
0C73  00FC 0000 0000 00EC              15 = LIT                                          04197000 D
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0C74  4809 0C52 0000 00F0        0 EOL B
0C75  6819 0000 0030 00F0        IF TRUE THEN SKIP
0C76  2380 0000 0C00 0060        CONTENTSPM - 1 = CPCR    % (R(M)) INTO B
0C77  4809 0C41 0B30 00F0        0 L = B
0C78  0000 0000 000C 0020        16 = SAR
0C79  4809 EC5C 1030 00F0        A3 OR B = A3             % A3 = (R(M))/INSTRUCTION
0C7A  633C 0000 0000 C060        IFETCH - 1 = CPCR        % "Y" INTO B
0C7B  4809 E0C0 AC30 00F0        A3 R = A2
0C7C  000C 0000 003C 0020        16 = SAR
0C7D  4809 CC40 C030 00F0        A2 + B = MIR             % Y INTO MIR
0C7E  4809 E0C0 903C 00F0        A3 R = A3
0C7F  30F0 0003 0000 0080        4 = SAR; 15 = LIT
0C80  4809 E155 0B70 00F0        A3 AND LIT = B           % ISOLATE "A"
0C81  51C0 0000 0000 C060        REGSTACK - 1 = CFCR
0C82  4809 0F41 002C C0F0        BMAR L = BR1             % TEMP STORAGE OF R(A)
0C83  000C 0000 0000 C030        COMP 8 = SAR
0C84  2F30 0000 003C C060        EINPUT - 1 = CPCR        % (R(A)) INTO B
0C85  4809 0C41 1030 00F0        B L = A3
0C86  0010 0000 003C 00A0        COMP 16 = SAR; 1 = LIT
0C87  4809 2F5C 001C 00F0        LIT OR BMAR = MAR2       % R(A+1)
0C88  2F30 C000 0030 C060        EINPUT - 1 = CPCR
0C89  4809 EC5C 2000 00F0        A3 OR B = A2, BMI        % A2 = (R(A))/(R(A+1)), B = Y
0C8A  4809 0C5E 0000 80F0        -B = SAR                 % SET UP SHIFT AMOUNT
0C8B  4809 C000 9000 00F0        A2 R = A3                % BITS LOST IN LEFT SHIFT
0C8C  4809 E002 0000 00F0        NOT A3
0C8D  63C9 C0C0 0000 00F0        IF NOT ABT THEN SET LC1
0C8E  5020 0003 000C C06C        OVBIT - 1 = CPCR         % SET THE OVERFLOW BIT
0C8F  4809 0C5E 0000 80F0        -B = SAR                 % SHIFT AMOUNT
0C90  49C9 C001 1B30 C0F0        A2 L = A3,B; SET LC1     % PERFORM SHIFT
0C91  20D0 0003 0000 C06C        SETCCA - 1 = CPCR        % SET THE CONDITION BITS
0C92  4809 E001 2000 C0F0        A3 L = A2                % (R(A+1)) INTO MS WORD OF A2
0C93  0000 0000 0000 002C        COMP 16 = SAR
0C94  4809 C000 8030 00F0        A2 R = MIR               % (R(A+1)) INTO MIR
0C95  2F50 0000 003C C06C        EOUTPUT - 1 = CPCR
0C96  4809 E0C0 803C 00F0        A3 R = MIR
0C97  4809 0000 000C 20F0        ASR                      % REFERENCE BR1
0C98  4809 CF43 801C C0F0        BMAR R = MAR2
0C99  0C00 0000 003C C010        8 = SAR
0C9A  2F5C 0003 0000 0060        EOUTPUT - 1 = CPCR
0C9B  66E0 0000 C000 C040        OPCODE - 1 = MPCR
                                                          %
                                                          %
                       OP163:                             % RX TYPE STORE AND INDEX BY 2
                                                          % (R(A),R(A+1)) INTO Y, Y+1
                                                          % (R(M)) + 2 INTO R(M)
0C9C  570C 0000 0C00 006C        RXMFIELD - 1 = CFCR      % Y INTO B
0C9D  4809 0C41 0C20 C0F0        B L = BR1                % TEMP STORAGE OF Y INTO BR1
0C9E  00C0 0000 0C30 0030        COMP 8 = SAR
0C9F  238C 0003 003C C060        CONTENTSRM - 1 = CPCR    % (R(M)) INTO B
0CA0  4809 2C40 0030 C0FC        LIT + B = MIR
0CA1  002C C0C0 0C3C 00E0        2 = LIT
0CA2  2F50 0003 0C00 C06C        EOUTPUT - 1 = CPCR       % (R(M)) + 2 INTO R(M)
0CA3  4809 E0C3 9000 00F0        A3 R = A3
0CA4  80FC 0003 C000 008C        4 = SAR; 15 = LIT
0CA5  4809 E156 0B0C 00F0        A3 AND LIT = B           % ISOLATE "A"
0CA6  51CC 0003 C030 0060        REGSTACK - 1 = CPCR      % ADDR OF R(A) INTO MAR2
0CA7  2F30 0003 0C00 0060        EINPUT - 1 = CPCR        % (R(A)) INTO B
0CA8  4809 0C40 C030 00F0        B = MIR
0CA9  4809 2F5C 1030 C0F0        LIT OR BMAR = A3         % R(A+1)
0CAA  001C 0003 0000 00E0        1 = LIT
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0CAB  4809 000D 0000 20F0             ASR                        % REFERENCE BR1                       04258000 D
0CAC  4809 0F43 001C 00F0             BMAR = BR2                 % ADDR OF Y INTO BR2                  04259000 D
0CAD  61E0 0000 0000 0060             EMULOUT - 1 = CPCR         % (R(A)) INTO Y                       04260000 D
0CAE  4809 0F47 0020 00F0             BMAR + 1 L = BR1           % ADDR OF Y + 1                       04261000 D
0CAF  0000 0003 0030 0030             COMP 8 = SAR                                                     04262000 D
0CB0  4809 E003 C01C 00F0             A3 = MAR2                                                        04263000 D
0CB1  2F3C C003 0000 006C             EINPUT - 1 = CPCR          % (R(A+1)) INTO B                     04264000 D
0CB2  4809 0C4C 0030 00F0             B = MIR                                                          04265000 D
0CB3  4809 C000 000C 20F0             ASR                        % REFERENCE BR1                       04266000 D
0CB4  4809 0F43 001C 00F0             BMAR = BR2                                                       04267000 D
0CB5  61E0 C000 0000 006C             EMULOUT - 1 = CPCR         % (R(A+1)) INTO Y+1                   04268000 D
0CB6  66EC 0000 0000 C040             OPCODE - 1 = MPCR                                                04269000 D
                                                                 %                                     04270000 D
                                                                 %                                     04271000 D
0CB7  5F9C 0000 000C 0060   OPCODE17:  XFCODE - 1 = CPCR         % "F" INTO A2                         04272000 D
0CB8  4809 C640 0090 C0F0             A2 + AMPCR = AMPCR                                               04273000 D
0CB9  1640 0CC0 0000 C0C0             OP17F - 1 = AMPCR                                                04274000 D
0CBA  4809 000D 0000 00F0             STEP                                                             04275000 D
0CBD  4824 000D 000C 00FC             EXEC                                                             04276000 D
                                                                 %                                     04277000 D
                                                                 %                                     04278000 D
0CBC  1650 000D 000C 004C   OP17F:    OP170 - 1 = MPCR                                                 04279000 D
0CBD  166C 0000 0000 0040             OP171 - 1 = MPCR                                                 04280000 D
0CBE  167C 0000 0030 C040             OP172 - 1 = MPCR                                                 04281000 D
0CDF  168C 000D 0000 C040             OP173 - 1 = MPCR                                                 04282000 D
                                                                 %                                     04283000 D
                                                                 %                                     04284000 D
                            OP170:                               % RR TYPE CIRCULAR DOUBLE LEFT SHIFT  04285000 D
                                                                 % SHIFT (R(A),R(A+1)) LEFT CIRCULARLY 04286000 D
                                                                 % (R(M)) (0-5) PLACES AND SET CC      04287000 D
0CC0  2380 C003 0000 C060             CONTENTSRM - 1 = CPCR      % (R(M)) INTO B                       04288000 D
0CC1  4809 CC40 2000 00F0             B = A2                                                           04289000 D
0CC2  48C9 E000 8800 C0F0             A3 R = B                                                         04290000 D
0CC3  80F0 0000 0000 0080             4 = SAR; 15 = LIT                                                04291000 D
0CC4  4809 2C56 0800 00F0             LIT AND B = B                                                    04292000 D
0CC5  51CC 0000 CC0C 0060             REGSTACK - 1 = CFCR                                              04293000 D
0CC6  4809 0F41 0020 00F0             BMAR L = BR1               % TEMP STORAGE OF R(A)                04294000 D
0CC7  001C C000 0000 00B0             COMP 8 = SAR; 1 = LIT                                            04295000 D
0CC8  4809 2F5C 001C 00F0             LIT OR BMAR = MAR2         % R(A+1)                              04296000 D
0CC9  2F3C 000D 0000 C060             EINPUT - 1 = CPCR          % (R(A)) INTO B                       04297000 D
0CCA  4809 0F45 001C C0FC             BMAR + 1 = MAR2                                                  04298000 D
0CCB  4809 CC41 1000 00FC             B L = A3                   % A3 HAS (R(A)) IN MS WORD            04299000 D
0CCC  000C 0000 0000 0020             COMP 16 = SAR                                                    04300000 D
0CCD  2F3C 00C0 0000 0060             EINPUT - 1 = CPCR          % (R(A+1)) INTO B                     04301000 D
0CCE  4809 EC5C 1030 00F0             A3 OR B = A3               % A3 = (R(A))/(R(A+1))                04302000 D
0CCF  4809 C002 2000 C0FC             NOT A2 = A2                                                      04303000 D
0CD0  4809 CCC0 C000 80F0             A2 + 1 = SAR               % COMP OF (R(M)) (0-5)                04304000 D
0CD1  49C9 E001 9B0C 00F0             A3 C = A3, B; SET LC1      % PERFORM SHIFT                       04305000 D
0CD2  2000 000D 0030 0060             SETCCA - 1 = CPCR          % SET THE CONDITION BITS              04306000 D
0CD3  48C9 E0C1 0B30 00F0             A3 L = B                   % (R(A+1)) INTO B                     04307000 D
0CD4  0000 00C0 0000 0020             COMP 16 = SAR                                                    04308000 D
0CD5  4809 0C40 8030 C0FC             B R = MIR                  % (R(A+1)) INTO MIR                   04309000 D
0CD6  2F50 0003 CC0C C060             EOUTPUT - 1 = CPCR         % WRITE SHIFTED (R(A+1))              04310000 D
0CD7  48C9 0003 000C 20F0             ASR                        % REFERENCE BR1                       04311000 D
0CD8  4809 0F43 8C1C C0F0             BMAR R = MAR2                                                    04312000 D
0CD9  000C 0000 C000 0010             8 = SAR                                                          04313000 D
0CDA  4809 E0C0 8030 00FC             A3 R = MIR                                                       04314000 D
0CDB  0000 C000 0030 002C             16 = SAR                                                         04315000 D
0CDC  2F5C 00C0 0C00 C06C             EOUTPUT - 1 = CPCR                                               04316000 D
0CDD  66E0 0000 C00C 004C             OPCODE - 1 = MPCR                                                04317000 D
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                                                        %                                           04319000 D
                          OP171:                        % RI TYPE 1 STORE ZERO, 0 INTO Y*           04320000 D
0CDE  2380 0000 0000 0060        CONTENTSRM - 1 = CPCR  % (R(M)) INTO B                             04321000 D
0CDF  4809 0C41 0010 00F0        B L = BR2                                                          04322000 D
0CE0  0000 0000 0C00 0030        COMP 8 = SAR                                                       04323000 D
0CE1  4809 00C0 0090 C0F0        0 = MIR                                                            04324000 D
0CE2  61E0 0000 0000 0060        EMULOUT - 1 = CPCR                                                 04325000 D
0CE3  66E0 0000 0000 0040        OPCODE - 1 = MPCR                                                  04326000 D
                                                        %                                           04327000 D
                                                        %                                           04328000 D
                          OP172:                        % RK TYPE CIRCULAR LEFT DOUBLE SHIFT        04329000 D
                                                        % SHIFT (R(A),R(A+1)) LEFT CIR. Y (0-5)     04330000 D
                                                        % AND SET CC                                04331000 D
0CE4  4809 2C56 0B00 00F0        LIT AND B = B                                                      04332000 D
0CE5  00F0 C000 0000 0CE0        15 = LIT                                                           04333000 D
0CE6  4809 0C52 C000 00F0        C EQL B                                                            04334000 D
0CE7  6819 0000 0000 00F0        IF TRUE THEN SKIP                                                  04335000 D
0CE8  238C 0000 0000 0060        CONTENTSRM - 1 = CPCR  % (R(M)) INTO B                             04336000 D
0CE9  4809 0C41 0B00 00F0        B L = B                                                            04337000 D
0CEA  0000 0000 0000 C020        COMP 16 = SAR                                                      04338000 D
0CEB  4809 EC5C 1000 00F0        A3 OR B = A3           % A3 = (R(M))/INSTRUCTION                   04339000 D
0CEC  6330 0000 0000 0060        IFETCH - 1 = CPCR      % "Y" INTO B                                04340000 D
0CED  4809 ECC0 A000 00F0        A3 R = A2              % (R(M)) INTO A2                            04341000 D
0CEE  000C 0000 0000 0020        16 = SAR                                                           04342000 D
0CEF  4809 CC40 2000 00FC        A2 + B = A2            % Y INTO A2                                 04343000 D
0CF0  4809 ECC0 9000 C0F0        A3 R = A3                                                          04344000 D
0CF1  30F0 0000 0000 0080        4 = SAR; 15 = LIT                                                  04345000 D
0CF2  4809 E155 0B00 C0F0        A3 AND LIT = B         % ISOLATE "A"                               04346000 D
0CF3  51C0 0000 0000 0060        REGSTACK - 1 = CPCR                                                04347000 D
0CF4  4809 0F4L 0C20 00F0        BMAR L = BR1           % TEMP STORAGE OF R(A)                      04348000 D
0CF5  001C 00C0 0000 C0B0        COMP 8 = SAR; 1 = LIT                                              04349000 D
0CF6  2F3C 0000 0000 0060        EINPUT - 1 = CPCR      % (R(A)) INTO B                             04350000 D
0CF7  4809 2F5C 001C C0F0        LIT OR BMAR = MAR2     % R(A+1)                                    04351000 D
0CF8  4809 0C41 1000 C0F0        P L = A3               % (R(A)) INTO FS WORD OF A3                 04352000 D
0CF9  000C 0000 0000 0020        COMP 16 = SAR                                                      04353000 D
0CFA  2F30 C000 0000 C060        EINPUT - 1 = CPCR      % (R(A+1)) INTO B                           04354000 D
0CFB  4809 EC5C 1000 00F0        A3 OR B = A3           % A3 = (R(A))/(R(A+1))                      04355000 D
0CFC  4809 C002 200C 00F0        NOT A2 = A2                                                        04356000 D
0CFD  4809 COC0 000C 80F0        A2 + 1 = SAR           % COMP OF Y (0-5)                           04357000 D
0CFE  49C9 EC01 9B00 C0F0        A3 C = A3,B; SET LC1   % PERFORM SHIFT                             04358000 D
0CFF  2000 00C0 C000 0060        SETCCA - 1 = CPCR      % SET THE CONDITION BITS                    04359000 D
0D00  4809 E001 2C00 C0F0        A3 L = A2                                                          04360000 D
0D01  0C0C 00C0 000C 0020        COMP 16 = SAR                                                      04361000 D
0D02  4809 C0C0 8090 C0F0        A2 R = MIR             % SHIFTED (R(A+1)) INTO MIF                 04362000 D
0D03  2F5C 0000 0000 006C        EOUTPUT - 1 = CPCR                                                 04363000 D
0D04  4809 0000 0000 20F0        ASR                    % REFERENCE BR1                             04364000 D
0D05  4809 0F40 8C1C C0FC        BMAR R = MAR2                                                      04365000 D
0D06  0000 0000 0000 C010        8 = SAR                                                            04366000 D
0D07  4809 E000 80BC 00F0        A3 R = MIR                                                         04367000 D
0D08  000C 0000 0000 C020        16 = SAR                                                           04368000 D
0D09  2F50 0000 000C 006C        EOUTPUT - 1 = CPCR                                                 04369000 D
0D0A  66E0 0000 0000 0040        OPCODE - 1 = MPCR                                                  04370000 D
                                                        %                                           04371000 D
                                                        %                                           04372000 D
                          OP173:                        % RX TYPE STORE ZERO, C INTO Y              04373000 D
0D0B  57C0 0000 0000 0060        RXMFIELD - 1 = CPCR    % ADDR OF Y INTO D                          04374000 D
0D0C  4809 0C41 0010 00F0        B L = BR2                                                          04375000 D
0D0D  0000 0000 000C C030        COMP 8 = SAR                                                       04376000 D
0D0E  4809 0CC0 0000 00F0        C = MIR                                                            04377000 D
```

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0010  66E0 0000 0000 0040          OPCODE - 1 = MPCR
                                                               *
                                                               *
0011  5F90 0000 0000 0060   OPCODE20:  XFCODE - 1 = CPCR       * "F" INTO A2
0012  4809 C640 0040 00F0          A2 + AMPCR = AMPCR
0013  1690 0000 0000 00C0          OP20F - 1 = AMPCR
0014  4809 0000 0000 00F0          STEP
0015  4824 0000 0000 00F0          FXEC
                                                               *
0016  16A0 0000 0000 0040   OP20F:     OP200 - 1 = MPCR
0017  16BC 0000 0000 0040          OP201 - 1 = MPCR
0018  16CC 0000 0000 0040          OP202 - 1 = MPCR
0019  16D0 0000 0000 C040          OP203 - 1 = MPCR
                                                               *
                                                               *
                            OP200:                             * RR TYPE SUBTRACT REGISTER
                                                               * (R(A)) - (R(M)) INTO R(A)
                                                               * SET CC, CARRY AND OVERFLOW
001A  2280 0000 0000 0060          CONTENTSRA - 1 = CPCR  * (R(A)) INTO B
001B  2809 0C41 2030 00F0          B L = A2; IF LC1       * (R(A)) INTO MS WORD OF A2
001C  00F0 0000 0000 00A0          COMP 16 = SAR; 15 = LIT
001D  4809 E155 0B30 00F0          A3 AND LIT = B
001E  51C0 0000 0020 006C          REGSTACK - 1 = CPCR
001F  2F30 0000 0000 0060          EINPUT - 1 = CPCR      * (R(M)) INTO B
0020  4849 0C41 0B00 00F0          B L = B; SET LC2
0021  4809 CC5E 0030 00F0          A2 - B = MIR           * (R(A)) - (R(M)) INTO MIR
0022  7BC9 0000 0030 00F0          IF AOV THEN SET LC1
0023  1E7C 0000 0000 0060          CARRY - 1 = CPCR       * SET THE CARRY BIT
0024  4F10 0000 0030 0060          CHECKOV - 1 = CPCR     * SET THE OVERFLOW BIT
0025  4809 0000 0030 00F0          BMI
0026  4809 CC40 8B30 00F0          B R = B,MIR
0027  00F0 0000 0000 0020          16 = SAR
0028  4809 E003 801C 00F0          A3 R = MAR2            * ADDR OF R(A)
0029  2F5C 0003 0000 0060          EOUTPUT - 1 = CPCR
002A  2CD0 0000 0000 0060          SETCCA - 1 = CPCR      * SET THE CONDITION BITS
002B  66E0 0003 0000 0040          OPCODE - 1 = MPCR
                                                               *
                                                               *
                            OP201:                             * RI TYPE 2 SUBTRACT (INDIRECT)
                                                               * (R(A)) - (Y*) INTO R(A),
                                                               * SET CC, CARRY, AND OV BITS
002C  2380 0C00 0030 0060          CONTENTSRM - 1 = CPCR  * (R(M)) INTO B
002D  4809 0C41 0020 C0FC          B L = BR1              * Y* INTO BR1
002E  0C0C 0000 0000 C030          COMP 8 = SAR
002F  4809 E000 0B00 00F0          A3 = B
0030  22BC 0003 0030 006C          CONTENTSRA - 1 = CPCR  * (R(A)) INTO B
0031  4809 0C41 2000 C0F0          B L = A2               * (R(A)) INTO MS WORD OF A2
0032  0000 0000 0030 0020          COMP 16 = SAR
0033  4809 0003 0000 20F0          ASR                    * REF BR1
0034  4809 0F43 0010 C0F0          BMAR = BR2
0035  60E0 0003 0000 0060          EMULIN - 1 = CPCR      * (Y*) INTO B
0036  4809 0C41 0B00 00F0          B L = B                * (Y*) INTO MS WORD OF B
0037  0000 0000 0030 0020          COMP 16 = SAR
0038  4849 CC5E 0030 00F0          A2 - B = MIR; SET LC2  * (R(A)) - (Y*) INTO MIR
0039  7BC9 0000 0030 00F0          IF AOV THEN SET LC1
003A  1E70 0000 0030 0060          CARRY - 1 = CPCR
003B  4F10 0000 0000 0060          CHECKOV - 1 = CPCR
003C  4809 0000 0000 00F0          BMI
003D  4809 0C43 8B3C 00F0          B R = B, MIR
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003E  0000 0000 0000 0020             16 = SAR                                                   04438000 D
003F  4809 E000 801C 00F0             A3 R = MAR2                % ADDR OF R(A)                  04439000 D
0040  2F50 0000 000C 0060             EOUTPUT - 1 = CPCR         % WRITE OUT NEW R(A)            04440000 D
0041  2000 0000 0000 0060             SETCCA - 1 = CPCR          % SET THE CONDITION BITS        04441000 D
0042  66E0 0000 000C 0040             OPCODE - 1 = MPCR                                          04442000 D
                                                                 %                               04443000 D
                                                                 %                               04444000 D
                          OP202:                                 %TYPE RK SUBTRACT, (R(A)) -Y INTO R(A)  04445000 D
                                                                 % SET CC, CARRY AND OV BITS     04446000 D
0043  4809 2C56 0800 00FC             LIT AND B = B              % "M" INTO B                    04447000 D
0044  00F0 0000 000C 00EC             15 = LIT                                                   04448000 D
0045  4809 CC52 0000 C0F0             C EOL B                                                    04449000 D
0046  6819 00C0 0000 C0F0             IF TRUE THEN SKIF                                          04450000 D
0047  2380 0000 000C 0060             CONTENTSRM - 1 = CPCR   % (R(M)) INTO B                    04451000 D
0048  4809 CC41 0890 00F0             B L = B                                                    04452000 D
0049  C000 0000 000C 0020             COMP 16 = SAR                                              04453000 D
004A  4809 EC5C 100C 00FC             A3 OR B = A3               % A3 = (R(M))/INSTRUCTION       04454000 D
004B  633C 0000 000C C06C             IFETCH - 1 = CPCR          % "Y" INTO B                    04455000 D
004C  4809 E000 AC0C 00F0             A3 R = A2                  % (R(M)) INTO A2                04456000 D
004D  000C 0000 000C 0020             16 = SAR                                                   04457000 D
004E  4809 CC41 0090 00F0             A2 + B L = MIR             % Y INTO MS WORD OF MIR         04458000 D
004F  4809 E000 080C 00FC             A3 = B                                                     04459000 D
0050  2280 0000 000C C060             CONTENTSRA - 1 = CPCR                                      04460000 D
0051  4809 0C41 2000 00F0             B L = A2, BMI              % (R(A)) INTO MS WORD OF A2     04461000 D
0052  000C 0000 0000 C02C             COMP 16 = SAR                                              04462000 D
0053  4849 CC5E 0090 00F0             A2 - B = MIR; SET LC2   % (R(A)) - (Y) INTO MIR            04463000 D
0054  78C9 0000 000C C0F0             IF AOV THEN SET LC1                                        04464000 D
0055  1E7C 0000 000C 006C             CARRY - 1 = CPCR           % SET THE CARRY BIT             04465000 D
0056  4F10 0000 0000 0060             CHECKOV - 1 = CPCR         % SET THE OV BIT                04466000 D
0057  4809 0000 000C 00F0             BMI                                                        04467000 D
0058  4809 0C40 889C 00F0             B R = D, MIR                                               04468000 D
0059  000C 0000 0000 C020             16 = SAR                                                   04469000 D
005A  2F50 C000 0000 0060             EOUTPUT - 1 = CPCR         % WRITE OUT NEW (R(A))          04470000 D
005B  2000 00C0 000C C060             SETCCA - 1 = CPCR          % SET THE CONDITION BITS        04471000 D
005C  56E0 0000 000C 0040             OPCODE - 1 = MPCR                                          04472000 D
                                                                 %                               04473000 D
                                                                 %                               04474000 D
                          OP203:                                 % TYPE RX SUBTRACT, (R(A))-(Y) -> R(A)  04475000 D
                                                                 % SET CC, CARRY AND OV BITS     04476000 D
005D  5700 0000 000C C060             RXMFIELD - 1 = CPCR        % ADDR OF Y INTO B              04477000 D
005E  4809 0C41 0010 00FC             B L = BR2                                                  04478000 D
005F  0000 0000 0000 0030             COMP 8 = SAR                                               04479000 D
0060  60EC 00C0 000C C06C             EMULIN - 1 = CPCR          % (Y) INTO B                    04480000 D
0061  4809 0C41 0090 00F0             D L = MIR                  % (Y) INTO MS WORD OF MIR       04481000 D
0062  000C 0000 0000 0020             COMP 16 = SAR                                              04482000 D
0063  4809 E000 080C 00F0             A3 = B                                                     04483000 D
0064  2280 0000 000C 0060             CONTENTSRA - 1 = CPCR   % (R(A)) INTO B                    04484000 D
0065  48C9 0C41 200C C0F0             B L = A2, BMI              % (R(A)) INTO MS WORD OF A2     04485000 D
0066  0000 0000 000C CC20             COMP 16 = SAR                                              04486000 D
0067  4849 CC5E 009C 00F0             A2 - B = MIR; SET LC2   % (R(A)) - (Y) INTO MIR            04487000 D
0068  78C9 0000 0000 00F0             IF AOV THEN SET LC1                                        04488000 D
0069  1E7C 0000 0000 0060             CARRY - 1 = CPCR                                           04489000 D
006A  4F1C 0000 0000 CC60             CHECKOV - 1 = CPCR                                         04490000 D
006B  4809 0000 000C C0FC             BMI                                                        04491000 D
006C  4809 0C40 889C 00F0             B R = B, MIR                                               04492000 D
006D  000C 0000 0000 C020             16 = SAR                                                   04493000 D
006E  2F5C C000 000C C060             EOUTPUT - 1 = CPCR         % WRITE NEW (R(A))              04494000 D
006F  200C 0000 000C 0060             SETCCA - 1 = CPCR          % SET THE CONDITION BITS        04495000 D
0070  56E0 0000 000C 0040             OPCODE - 1 = MPCR                                          04496000 D
                                                                 %                               04497000 D
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0D71  5F90 C000 0000 0060   OPCODE21:  XFCODE - 1 = CPCR      % "F" INTO A2
0D72  4809 C640 0040 00FC              A2 + AMPCR = AMPCR
0D73  16EC 00C0 0030 00C0              OP21F - 1 = AMPCR
0D74  4809 09C0 0000 00F0              STEP
0D75  4824 C000 000C C0F0              EXEC
                                                              %
0D76  16FC C000 0030 0040   OP21F:     OP210 - 1 = MPCR
0D77  1700 0000 0000 0040              OP211 - 1 = MPCR
0D78  300C C000 0030 0040              FAULT - 1 = MPCR
0D79  171C 0003 0000 004C              OP213 - 1 = MPCR
                                                              %
                                                              %
                            OP210:                            % TYPE RR SUBTRACT DOUBLE (REGISTER)
                                                              % (R(A),R(A+1))-(R(M),R(M+1)) INTO
                                                              % R(A),R(A+1), SET CC, OV, AND CARRY
0D7A  4809 0C40 8B00 00F0              B R = B                % ISOLATE "A"
0D7B  90F0 00C0 0030 C080              4 = SAR; 15 = LIT
0D7C  4809 2C55 0B00 00F0              LIT AND B = B
0D7D  51CC C000 0070 0060              REGSTACK - 1 = CPCR
0D7E  2F3C 00C0 0C00 006C              EINPUT - 1 = CPCR      % (R(A)) INTO B
0D7F  4809 0C41 2030 C0F0              B L = A2               % (R(A)) INTO MS WORD OF A2
0D80  0000 0003 0000 C020              COMP 16 = SAR
0D81  4809 0F4L 002C 00FC              BMAR L = BR1           % TEMP STORAGE OF ADDR OF R(A)
0D82  001C 00C0 0030 0080              COMP 8 = SAR; 1 = LIT
0D83  4809 2F5C 0C1C 00F0              LIT OR BMAR = MAR2     % R(A+1)
0D84  2F3C 0000 C00C C060              EINPUT - 1 = CPCR      % (R(A+1)) INTO B
0D85  4809 CC5C 2030 00F0              A2 OR D = A2           % A2 = (R(A))/(R(A+1))
0D86  4809 E156 0E30 C0F0              A3 AND LIT = B         % ISOLATE "M"
0D87  00F0 0000 0030 00EC              15 = LIT
0D88  51C0 0000 0C00 0C60              REGSTACK - 1 = CPCR
0D89  2F3C 0003 0000 0060              EINPUT - 1 = CPCR      % (R(M)) INTO B
0D8A  4809 0C41 103C 00F0              B L = A3               % (R(M)) INTO MS WORD OF A3
0D8B  0010 00C3 000C 00A0              COMP 16 = SAR; 1 = LIT
0D8C  4809 2F5C 0C1C 00FC              LIT OR BMAR = MAR2     % ADDR OF R(M+1)
0D8D  2F30 0000 0000 C060              EINPUT - 1 = CPCR      % (R(M+1)) INTO B
0D8E  4809 EC5C CB30 00F0              A3 OR B = B            % D = (R(M))/(R(M+1))
0D8F  4849 CC5E C080 C0F0              A2 - D = MIR; SET LC2  % PERFORM SUBTRACTION
0D90  7BC9 0C00 0030 00F0              IF AOV THEN SET LC1
0D91  1E70 0003 000C C060              CARRY - 1 = CPCR
0D92  4F10 C000 000C C060              CHECKOV - 1 = CPCR
0D93  49C9 CCC0 0D00 C0F0              BMI; SET LC1
0D94  20DC 0CC0 C00C 0060              SETCCA - 1 = CPCR      % SET THE CONDITION BITS
0D95  4809 00C3 0D30 00F0              BMI
0D96  4809 0C40 8C30 C0F0              B R = MIR              % NEW (R(A)) INTO MIR
0D97  C000 0CC0 0C3C 002C              16 = SAR
0D98  4809 CC41 CB30 C0F0              B L = B
0D99  4809 0C40 880C 00F0              B R = B                % (R(A+1))
0D9A  4809 00C3 0030 20F0              ASR                    % REFERENCE BR1
0D9B  4809 0F43 901C 00F0              BMAR R = MAR2, A3      % ADDR OF R(A)
0D9C  000C 0CC0 0000 001C              8 = SAR
0D9D  2F5C C0C3 0C30 006C              EOUTPUT - 1 = CPCR     % WRITE NEW (R(A))
0D9E  4809 EDDC 001C C0F0              A3 OR 1 = MAR2         % ADDR OF R(A+1)
0D9F  4809 0C40 0C90 00F0              B = MIR                % (R(A+1))
0DA0  2F5C 0000 000C C06C              EOUTPUT - 1 = CPCR     % WRITE NEW (R(A+1))
0DA1  66EC C000 0030 C040              OPCODE - 1 = MPCR
                                                              %
                                                              %
                            OP211:                            % RI TYPE 2 SUBTRACT DOUBLE
                                                              % (R(A),R(A+1))-(Y*,Y*+1) INTO
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                                                                   %R(A),R(A+1), SET CC, CARRY AND OV BITS
0DA2  4809 0C40 8030 00F0              B R = B
0DA3  80F0 0000 0000 C080              4 = SAR; 15 = LIT
0DA4  4809 2C55 0030 00F0              LIT AND B = B           % ISOLATE "A"
0DA5  51C0 0000 0000 C060              REGSTACK - 1 = CPCR
0DA6  2F30 0000 0000 C060              EINPUT - 1 = CPCR       % (R(A)) INTO B
0DA7  4809 0C41 2030 C0F0              B L = A2                % (R(A)) INTO MS WORD OF A2
0DA8  0000 0000 0000 C020              COMP 16 = SAR
0DA9  4809 0F41 0020 00F0              BMAR L = BR1            % SAVE ADDR OF R(A)
0DAA  0010 0000 0000 C080              COMP 8 = SAR; 1 = LIT
0DAB  4809 2F5C 0C1C 00F0              LIT OR BMAR = MAR2      % R(A+1)
0DAC  2F30 0000 0000 C060              EINPUT - 1 = CPCR       % (R(A+1)) INTO B
0DAD  4809 CC5C 2030 C0F0              A2 OR B = A2            % A2 = (R(A))/(R(A+1))
0DAE  4809 E156 0800 00F0              A3 AND LIT = B          % ISOLATE "M"
0DAF  00FC 0000 0000 C0E0              15 = LIT
0DB0  51C0 0000 0000 006C              REGSTACK - 1 = CPCR     % (R(M)) INTO B
0DB1  2F30 C000 0000 0060              EINPUT - 1 = CPCR       % (R(M)) INTO B
0DB2  4809 0C41 0C10 C0F0              B L = BR2
0DB3  0000 0C00 0000 003C              COMP 8 = SAR
0DB4  60E0 0000 0000 0060              EMULIN - 1 = CPCR       % (Y*) INTO B
0DB5  4809 2F53 001C 00F0              LIT OR BMAR L = ER2     % ADDR OF Y*+1
0DB6  0010 C000 0000 00B0              COMP 8 = SAR; 1 = LIT
0DB7  4809 0C41 1030 C0FC              B L = A3                % (Y*) INTO MS WORD OF A3
0DB8  0000 0000 0000 0020              COMP 16 = SAR
0DB9  60E0 0000 0000 0060              EMULIN - 1 = CPCR       % (Y*+1) INTO B
0DBA  4809 EC5C 0B00 C0F0              A3 OR B = B             % B = (Y*)/(Y*+1)
0DBB  4849 CC5E 0C90 00F0              A2 - D = MIR; SET LC2   % PERFORM SUBTRACTION
0DBC  78C9 0000 0000 00F0              IF AOV THEN SET LC1
0DBD  1E70 0000 0000 0C60              CARRY - 1 = CPCR
0DBE  4F1C 0C00 0000 0060              CHECKOV - 1 = CPCR      % SET THE OV BITS
0DBF  49C9 0000 0D00 00F0              BMI; SET LC1
0DC0  20D0 0000 0000 0060              SETCCA - 1 = CPCR       % SET THE CONDITION BITS
0DC1  4809 0000 0000 00FC              BMI
0DC2  4809 0C40 8030 00F0              B R = MIR               % NEW (R(A))
0DC3  0000 0000 0000 0020              16 = SAR
0DC4  4809 0C41 0B30 00F0              B L = B
0DC5  4809 0C40 8B30 00F0              B R = B                 % NEW (R(A+1))
0DC6  4809 0003 0030 20FC              ASR                     % REF BR1
0DC7  4809 0F43 8C1C 00F0              BMAR R = MAR2           % ADDR OF R(A)
0DC8  0010 C000 0C00 C09C              8 = SAR; 1 = LIT
0DC9  2F50 0000 0000 0060              EOUTPUT - 1 = CPCR      % WRITE NEW (R(A))
0DCA  4809 2F5C 001C 00FC              LIT OR BMAR = MAR2      % R(A+1)
0DCB  4809 0C40 0030 00F0              B = MIR                 % (R(A+1))
0DCC  2F5C 0000 0000 006C              EOUTPUT - 1 = CPCR      % WRITE NEW (R(A+1))
0DCD  66EC 0000 C000 0040              OPCODE - 1 = MPCR
                                                               %
                                                               %
                              OP213:                           % RX TYPE SUBTRACT DOUBLE
                                                               % (R(A),R(A+1))-(Y,Y+1)=R(A),R(A+1)
                                                               % SET CC, OV AND CARRY BITS
0DCE  5700 0000 0000 0060              RXMFIELD - 1 = CPCR     % Y ADDR INTO B
0DCF  4809 0C41 0C10 00FC              B L = BR2
0DD0  0000 0000 0000 0030              COMP 8 = SAR
0DD1  60EC 0000 0000 C060              EMULIN - 1 = CPCR       % (Y) INTO B
0DD2  4809 0C41 2030 00F0              B L = A2                % (Y) INTO MS WORD OF A2
0DD3  0000 0000 0000 Q020              COMP 16 = SAR
0DD4  4809 2F53 0C1C C0F0              LIT OR BMAR L = ER2     % ADDR OF Y+1
0DD5  0010 0000 C000 00B0              COMP 8 = SAR ; 1 = LIT
0DD6  60E0 0000 0C00 C060              EMULIN - 1 = CPCR       % (Y+1) INTO B
0DD7  4809 CC5C 0030 00FC              A2 OR B = MIR           % MIR = (Y)/(Y+1)
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0DD8  4809 E000 0800 C0FC        A3 = B                                                     04618000 D
0DD9  4609 0C40 8E30 C0F0        B R = B                                                    04619000 D
0DDA  80F0 0000 0000 C080        4 = SAR; 15 = LIT                                          04620000 D
0DDB  4809 2C55 0B00 C0F0        LIT AND B = B                                              04621000 D
0DDC  51CC 0000 C0C0 006C        REGSTACK - 1 = CPCR                                        04622000 D
0DDD  2F30 0000 0000 C06C        EINPUT - 1 = CPCR       % (R(A)) INTO B                    04623000 D
0DDE  4809 0F41 0C20 C0F0        BMAR L = BR1            % SAVE ADDR OF R(A)                04624000 D
0DDF  0000 0CC0 0000 C030        COMP 8 = SAR                                               04625000 D
0DE0  4809 0C41 2C00 00FC        B L = A2                % (R(A)) INTO MS WORD OF A2        04626000 D
0DE1  001C 0000 0000 C0A0        COMP 16 = SAR; 1 = LIT                                     04627000 D
0DE2  4809 2F5C C01C C0FC        LIT OR BMAR = MAR2      % R(A+1)                           04628000 D
0DE3  2F30 0000 0000 C060        EINPUT - 1 = CPCR       % (R(A+1)) INTO B                  04629000 D
0DE4  48C9 CC5C 2D00 00F0        A2 OR B = A2, BMI       % A2 = (R(A))/(R(A+1))             04630000 D
0DE5  4849 CC5E 0050 00FC        A2 - B = MIR; SET LC2   % PERFORM SUBTRACTION              04631000 D
0DE6  78C9 C000 0000 00FC        IF AOV THEN SET LC1                                        04632000 D
0DE7  1E70 0CC0 0000 C060        CARRY - 1 = CPCR                                           04633000 D
0DE8  4F1C 0000 000C C060        CHECKOV - 1 = CPCR                                         04634000 D
0DE9  49C9 00C0 0DD0 00FC        BMI; SET LC1                                               04635000 D
0DEA  200C 0000 0000 006C        SETCCA - 1 = CPCR       % SET THE CONDITION BITS           04636000 D
0DEB  4809 0000 C000 C0F0        BMI                                                        04637000 D
0DEC  4809 0C40 8050 00F0        B R = MIR               % NEW (R(A))                       04638000 D
0DED  0000 C000 0C00 C02C        16 = SAR                                                   04639000 D
0DEE  4809 0C41 0B00 C0FC        B L = B                                                    04640000 D
0DEF  4809 CC40 8600 00F0        B R = B                                                    04641000 D
0DF0  4809 00C0 0FC0 20F0        ASR                     % REF BR1                          04642000 D
0DF1  4809 0F40 901C C0FC        BMAR R = MAR2  , A3                                        04643000 D
0DF2  C00C 0000 C000 0010        8 = SAR                                                    04644000 D
0DF3  2F50 0CC0 0000 006C        EOUTPUT - 1 = CPCR      % WRITE NEW (R(A))                 04645000 D
0DF4  4809 E0DC C01C 0DFC        A3 OR 1 = MAR2          % ADDR OF R(A+1)                   04646000 D
0DF5  4809 0C40 0C3C 00F0        B = MIR                                                    04647000 D
0DF6  2F5C 0CC0 000C C06C        EOUTPUT - 1 = CPCR      % WRITE NEW (R(A+1))               04648000 D
0DF7  66EC 0C00 C00C C040        OPCODE - 1 = MPCR                                          04649000 D
                                                         %                                  04650000 D
                                                         %                                  04651000 D
0DF8  5F9C 00C0 0C0C C060  OPCODE22:  XFCODE - 1 = CPCR  % "F" INTO A2                      04652000 D
0DF9  4809 C640 0C40 C0F0        A2 + AMPCR = AMPCR                                         04653000 D
0DFA  1720 0CC0 0C0C 00CC        OP22F - 1 = AMPCR                                          04654000 D
0DFB  4809 0000 0C0C CCF0        STEP                                                       04655000 D
0DFC  4824 0CC0 C0D0 00F0        EXEC                                                       04656000 D
                                                         %                                  04657000 D
0DFD  173C CC00 0C0C C04C  OP22F:  OP220 - 1 = MPCR                                         04658000 D
0DFE  174C 00C0 0C00 0040        OP221 - 1 = MPCR                                           04659000 D
0DFF  175C 0CC0 000C C040        OP222 - 1 = MPCR                                           04660000 D
0E00  176C 0C00 0C0C 0040        OP223 - 1 = MPCR                                           04661000 D
                                                         %                                  04662000 D
                                                         %                                  04663000 D
                           OP220:                        % TYPE RR ADD, (R(A)) + (R(M)) -> R(A)   04664000 D
                                                         % SET CC, CARRY AND OV BITS        04665000 D
0E01  2280 00C0 0CC0 0060        CONTENTSRA - 1 = CPCR   % (R(A)) INTO B                    04666000 D
0E02  4809 0C41 2C0C C0F0        B L = A2                                                   04667000 D
0E03  00FC C000 CC0C 00A0        COMP 16 = SAR; 15 = LIT                                    04668000 D
0E04  4809 E156 0B0C 00FC        A3 AND LIT = B                                             04669000 D
0E05  51CC CCC0 0C00 CC60        REGSTACK - 1 = CPCR     % ADDR OF R(M) INTO MAR2           04670000 D
0E06  2F3C 00C0 CC0C C060        EINPUT - 1 = CPCR       % (R(M)) INTO B                    04671000 D
0E07  4809 0C41 0B00 C0FC        B L = B                                                    04672000 D
0E08  000C 00C0 0C0C 0020        COMP 16 = SAR                                              04673000 D
0E09  4809 CC40 0C3C 0CF0        A2 + B = MIR            % PERFORM ADDITION                 04674000 D
0E0A  78C9 0CC0 000C 00F0        IF AOV THEN SET LC1                                        04675000 D
0E0B  1E7C 0CC0 C0D0 0060        CARRY - 1 = CPCR                                           04676000 D
0E0C  4F1C C000 C00C C060        CHECKOV - 1 = CPCR                                         04677000 D
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0E0E  0000 0000 0000 0020        16 = SAR                                                      04679000 D
0E0F  4809 0C40 8B30 C0FC        B R = MIR, B                                                  04680000 D
0E10  2F50 0000 0000 0060        EOUTPUT - 1 = CPCR                                            04681000 D
0E11  2000 0000 0000 0060        SETCCA - 1 = CPCR      % SET THE CONDITION BITS               04682000 D
0E12  66E0 0000 0000 0040        OPCODE - 1 = MPCR                                             04683000 D
                                                        %                                      04684000 D
                                                        %                                      04685000 D
                          OP221:                        % TYPE RI TYPE 2 ADD, (R(A))+(Y*) ->   04686000 D
                                                        % R(A), SET CC, CARRY, AND OV BITS     04687000 D
0E13  228C 0000 0000 0060        CONTENTSRA - 1 = CPCR  % (R(A)) INTO B                        04688000 D
0E14  4809 0C41 2C30 00FC        B L = A2               % (R(A)) INTO MS WORD OF A2            04689000 D
0E15  00FC 0C03 0030 00A0        COMP 16 = SAR; 15 = LIT                                       04690000 D
0E16  4809 E156 0B30 00F0        A3 AND LIT = B                                                04691000 D
0E17  51CC 0000 C000 C06C        REGSTACK - 1 = CPCR                                           04692000 D
0E18  2F30 0003 0000 0060        EINPUT - 1 = CPCR      % (R(M)) INTO B                        04693000 D
0E19  4809 0C41 C010 00FC        B L = BR2                                                     04694000 D
0E1A  000C 0C00 0000 0030        COMP B = SAR                                                  04695000 D
0E1B  6CE0 00CD 0C30 006C        EMULIN - 1 = CPCR      % (Y*) INTO B                          04696000 D
0E1C  4809 0C41 0B0C 00F0        B L = B                % (Y*) INTO MS WORD OF B               04697000 D
0E1D  0C0C 0003 0030 002C        COMP 16 = SAR                                                 04698000 D
0E1E  4809 CC40 0030 00F0        A2 + B = MIR                                                  04699000 D
0E1F  7BC9 0000 C030 CCF0        IF AOV THEN SET LC1                                           04700000 D
0E20  1E7C 00C3 0000 C060        CARRY - 1 = CPCR                                              04701000 D
0E21  4F1C 0000 0000 C060        CHECKOV - 1 = CPCR                                            04702000 D
0E22  4809 E0C3 8D1C C0F0        A3 R = MAR2, BMI       % ADDR OF R(A)                         04703000 D
0E23  000C 0003 0030 0020        16 = SAR                                                      04704000 D
0E24  4809 0C40 8B30 C0F0        B R = MIR, B                                                  04705000 D
0E25  2F50 0000 0000 0060        EOUTPUT - 1 = CPCR     % WRITE NEW (R(A))                     04706000 D
0E26  200C 0003 0030 0060        SETCCA - 1 = CPCR                                             04707000 D
0E27  66E0 0000 0000 C040        OPCODE - 1 = MPCR                                             04708000 D
                                                        %                                      04709000 D
                                                        %                                      04710000 D
                          OP222:                        % TYPE RK ADD, (R(A))+Y -> R(A)        04711000 D
                                                        % SET CC, CARRY AND OV BITS            04712000 D
0E28  4809 2C56 0B30 00F0        LIT AND B = B                                                 04713000 D
0E29  00FC C000 0000 C0E0        15 = LIT                                                      04714000 D
0E2A  4809 0C52 0030 00F0        C EQL B                                                       04715000 D
0E2B  5819 C0C0 0030 0CFC        IF TRUE THEN SKIP                                             04716000 D
0E2C  238C 0CC0 000C 0060        CONTENTSRM - 1 = CPCR  % (R(M)) INTO B                        04717000 D
0E2D  4809 0C41 0B30 00FC        B L = B                % (R(M)) INTO MS WORD OF B             04718000 D
0E2E  0000 00C3 0C00 C020        COMP 16 = SAR                                                 04719000 D
0E2F  4809 EC5C 103C C0FC        A3 OR B = A3           % A3 = (R(M))/INSTRUCTION              04720000 D
0E30  6330 0000 C030 0060        IFETCH - 1 = CPCR      % "Y" INTO B                           04721000 D
0E31  4809 E000 A00C 00FC        A3 R = A2              % (R(M)) INTO A2                       04722000 D
0E32  0000 C0C0 000C 0020        16 = SAR                                                      04723000 D
0E33  4809 CC41 0030 C0FC        A2 + B L = MIR         % Y INTO MIR                           04724000 D
0E34  4809 E0C3 0B3C C0F0        A3 = B                                                        04725000 D
0E35  228C 0000 0030 C060        CONTENTSRA - 1 = CPCR  % (R(A)) INTO B                        04726000 D
0E36  4809 0C41 2D30 C0F0        B L = A2, BMI          % (R(A)) INTO MS WORD OF A2            04727000 D
0E37  0000 00C0 0000 C02C        COMP 16 = SAR                                                 04728000 D
0E38  4809 CC40 003C 00F0        A2 + B = MIR           % PERFORM ADDITION                     04729000 D
0E39  7BC9 C000 0000 00F0        IF AOV THEN SET LC1                                           04730000 D
0E3A  1E7C 0000 0030 C06C        CARRY - 1 = CPCR                                              04731000 D
0E3B  4F10 0003 003C C06C        CHECKOV - 1 = CPCR                                            04732000 D
0E3C  4809 0003 0000 00F0        BMI                                                           04733000 D
0E3D  4809 0C40 8B30 C0F0        B R = B, MIR                                                  04734000 D
0E3E  0000 0000 0030 C02C        16 = SAR                                                      04735000 D
0E3F  2F50 C000 0000 C060        EOUTPUT - 1 = CPCR                                            04736000 D
0E40  2000 0003 0030 006C        SETCCA - 1 = CPCR      % SET THE CONDITION BITS               04737000 D
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0E41  56EC 0000 000C C040                OPCODE - 1 = MPCR
                                                                  *
                                                                  *
                                OP223:                            * RX TYPE ADD, (R(A))+(Y) -> R(A)
                                                                  * SET CC, CARRY, AND OV BITS
0E42  570C 0000 0020 006C                RXMFIELD - 1 = CPCR      * Y INTO B
0E43  4809 CC41 001C 00F0                B L = BR2
0E44  000C 0000 000C 003C                COMP 8 = SAR
0E45  50E0 0000 0000 C060                EMULIN - 1 = CPCR        * (Y) INTO B
0E46  4809 0C41 0030 C0F0                B L = MIR                * (Y) INTO MS WORD OF MIR
0E47  000C 0000 000C C020                16 = SAR
0E48  4809 E000 0B0C C0F0                A3 = B
0E49  22BC 0000 C000 0060                CONTENTSRA - 1 = CPCR    * (R(A)) INTO B
0E4A  4809 0C41 2000 C0F0                B L = A2, BMI
0E4B  000C 0000 000C CC2C                COMP 16 = SAR
0E4C  4809 CC40 003C C0F0                A2 + B = MIR             * PERFORM ADDITION
0E4D  7BC9 00C0 0000 C0FC                IF AOV THEN SET LC1
0E4E  1E70 0000 000C 0060                CARRY - 1 = CPCR
0E4F  4F10 0000 0030 C06C                CHECKOV - 1 = CPCR
0E50  4809 C000 000C 00F0                BMI
0E51  4809 0C40 8B3C C0F0                B R = MIR, B
0E52  0000 0000 C03C 0020                16 = SAR
0E53  2000 C000 0000 0060                SETCCA - 1 = CPCR        * SET THE CONDITION BITS
0E54  2F5C 0000 0000 0060                EOUTPUT - 1 = CPCR
0E55  56E0 0000 000C 0C40                OPCODE - 1 = MPCR
                                                                  *
                                                                  *
0E56  5F90 0000 0C00 C060       OPCODE23:  XFCODE - 1 = CPCR      * "F" INTO A2
0E57  4809 C640 0030 C0F0                A2 + AMPCR = AMPCR
0E58  1770 0000 0000 00C0                OP23F - 1 = AMPCR
0E59  4809 0000 003C C0F0                STEP
0E5A  4824 0000 000C C0FC                EXEC
                                                                  *
0E5B  1780 C000 0000 0040       OP23F:   OP230 - 1 = MPCR
0E5C  179C 0000 003C C040                OP231 - 1 = MPCR
0E5D  300C 0000 000C C040                FAULT - 1 = MPCR
0E5E  17A0 0000 0000 C040                OP233 - 1 = MPCR
                                                                  *
                                                                  *
                                OP230:                            * TYPE RR ADD DOUBLE, (R(A)),R(A+1)) +
                                                                  * (R(M),R(M+1)) INTO R(A),R(A+1)
                                                                  * SET CC, CARRY AND OV BITS
0E5F  4809 2C56 0B3C C0FC                LIT AND B = B            * ISOLATE "M"
0E60  00F0 0000 0C3C 00E0                15 = LIT
0E61  51CC 0000 0000 C060                REGSTACK - 1 = CPCR
0E62  2F3C 0000 0000 0060                EINPUT - 1 = CPCR        * (R(M)) INTO B
0E63  4809 0C41 203C 00FC                B L = A2                 * (R(M)) INTO MS WORD OF A2
0E64  001C 0000 0030 C0A0                COMP 16 = SAR ; 1 = LIT
0E65  4809 2F5C 001C C0F0                LIT OR BMAR = MAR2       * ADDR OF R(M+1)
0E66  2F3C 0000 0000 C06C                EINPUT - 1 = CPCR        * (R(M+1)) INTO B
0E67  4809 CC5C 003C 00F0                A2 OR B = MIR            * MIR = (R(M))/(R(M+1))
0E68  4809 E000 8B0C C0FC                A3 R = B
0E69  90FC 0000 0000 C08C                4 = SAR; 15 = LIT
0E6A  4809 2C56 0BDC 00FC                LIT AND B = B            * ISOLATE "A"
0E6B  51C0 C000 0030 0060                REGSTACK - 1 = CPCR
0E6C  4809 CF41 002C C0FC                BMAR L = BR1             * TEMP STORAGE
0E6D  000C 0000 C000 003C                COMP 8 = SAR
0E6E  2F3C 0000 0000 C060                EINPUT - 1 = CPCR        * (R(A)) INTO B
0E6F  4809 CC41 2030 00FC                B L = A2                 * (R(A)) INTO MS WORD OF A2
0E70  0010 0000 000C C0A0                COMP 16 = SAR ; 1 = LIT
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0E71  4809 2F5C 0C1C 00F0          LIT OR BMAR = MAR2         * R(A+1)
0E72  2F30 0000 0000 C060          EINPUT - 1 = CPCR          * (R(A+1)) INTO B                             04799000 D
0E73  4809 CC5C 2000 C0F0          A2 OR B = A2, BMI          * A2 = (R(A))/(R(A+1))                        04800000 D
0E74  4809 CC40 0090 C0FC          A2 + B = MIR               * PERFORM ADDITION                            04801000 D
0E75  78C9 0000 C000 C0FC          IF AOV THEN SET LC1                                                      04802000 D
0E76  1E70 0000 0000 006C          CARRY - 1 = CPCR                                                         04803000 D
0E77  4F1C 0000 0000 0060          CHECKOV - 1 = CPCR                                                       04804000 D
0E78  49C9 0000 0D00 C0F0          BMI; SET LC1                                                             04805000 D
0E79  2000 C0C0 000C C060          SETCCA - 1 = CPCR          * SET THE CONDITION BITS                      04806000 D
0E7A  4809 0C00 000C C0F0          BMI                                                                      04807000 D
0E7B  4809 0C41 2C00 C0F0          B L = A2                                                                 04808000 D
0E7C  000C 00C0 0C00 C020          COMP 16 = SAR                                                            04809000 D
0E7D  4809 C000 8C9C 00F0          A2 R = MIR                 * (R(A+1))                                    04810000 D
0E7E  4809 0C40 8800 00FC          B R = B                    * (R(A))                                      04811000 D
0E7F  2F50 C000 0C00 0060          EOUTPUT - 1 = CPCR         * WRITE NEW (R(A+1))                          04812000 D
0E80  4809 C0C0 C000 20FC          ASR                        * REF BR1                                     04813000 D
0E81  4809 0F40 8C1C 00FC          BMAR R = MAR2              * R(A)                                        04814000 D
0E82  0000 0000 0C00 001C          B = SAR                                                                  04815000 D
0E83  4809 CC40 0090 00F0          B = MIR                                                                  04816000 D
0E84  2F5C 0000 0000 0060          EOUTPUT - 1 = CPCR         * WRITE NEW R(A)                              04817000 D
0E85  56E0 00C0 0000 0040          OPCODE - 1 = MPCR                                                        04818000 D
                                                              *                                             04819000 D
                                                              *                                             04820000 D
                           OP231:                             * RI TYPE 2 ADD DOUBLE                        04821000 D
                                                              * (R(A),R(A+1))+(Y*,Y*+1) INTO                04822000 D
                                                              * R(A),R(A+1), SET CC, CARRY AND OV BITS      04823000 D
0E86  2380 0C00 0C0C 006C          CONTENTSRM - 1 = CPCR                                                    04824000 D
0E87  4809 0C41 0C1C 00F0          B L = BR2                  * Y* INTO BR2                                 04825000 D
0E88  C000 00C0 0000 0030          COMP 8 = SAR                                                             04826000 D
0E89  60E0 0000 000C 0060          EMULIN - 1 = CPCR          * (Y*) INTO B                                 04827000 D
0E8A  4809 0C41 2000 00F0          B L = A2                   * (Y*) INTO MS WORD OF A2                     04828000 D
0E8B  0C0C 00C0 0C00 0020          COMP 16 = SAR                                                            04829000 D
0E8C  48C9 CF47 0C10 00FC          BMAR + 1 L = BR2                                                         04830000 D
0E8D  000C 00C0 C000 C030          COMP 8 = SAR                                                             04831000 D
0E8E  6CEC 0000 0C0C 006C          EMULIN - 1 = CPCR          * (Y*+1) INTO B                               04832000 D
0E8F  4809 CC5C 0C9C 00F0          A2 OR B = MIR              * MIR = (Y*)/(Y*+1)                           04833000 D
0E90  48C9 E000 900C 00F0          A3 R = A3                                                                04834000 D
0E91  8CFC 0000 0000 C080          4 = SAR; 15 = LIT                                                        04835000 D
0E92  4809 E156 0E00 00F0          A3 AND LIT = B                                                           04836000 D
0E93  51C0 0000 0000 0060          REGSTACK - 1 = CPCR                                                      04837000 D
0E94  48C9 0F41 002C 00FC          BMAR L = BR1               * TEMP STORAGE FOR R(A)                       04838000 D
0E95  00CC 00C0 C000 003C          COMP 8 = SAR                                                             04839000 D
0E96  2F3C 0CC0 C000 0060          EINPUT - 1 = CPCR          * (R(A)) INTO B                               04840000 D
0E97  4809 0C41 2000 00F0          B L = A2                   * (R(A)) INTO MS WORD OF A2                   04841000 D
0E98  0010 0000 0000 C0A0          COMP 16 = SAR; 1 = LIT                                                   04842000 D
0E99  48C9 2F5C 001C C0F0          LIT OR BMAR = MAR2         * R(A+1)                                      04843000 D
0E9A  2F30 0C00 0000 0060          EINPUT - 1 = CPCR          * (R(A+1)) INTO B                             04844000 D
0E9B  4809 CC5C 2000 C0F0          A2 OR B = A2, BMI          * A2 = (R(A))/(R(A+1))                        04845000 D
0E9C  48C9 CC40 0090 00FC          A2 + B = MIR               * PERFORM ADDITION                            04846000 D
0E9D  78C9 0000 C000 00FC          IF AOV THEN SET LC1                                                      04847000 D
0E9E  1E70 0000 0000 C060          CARRY - 1 = CPCR                                                         04848000 D
0E9F  4F1C 0000 0C00 006C          CHECKOV - 1 = CPCR                                                       04849000 D
0EA0  49C9 0000 0D00 00FC          BMI; SET LC1                                                             04850000 D
0EA1  200C C000 0000 C060          SETCCA - 1 = CPCR          * SET THE CONDITION BITS                      04851000 D
0EA2  4809 0000 0D0C C0F0          BMI                                                                      04852000 D
0EA3  4809 0C41 2000 C0F0          B L = A2                                                                 04853000 D
0EA4  0000 0000 0000 0020          COMP 16 = SAR                                                            04854000 D
0EA5  4809 C000 8090 00FC          A2 R = MIR                 * NEW (R(A+1))                                04855000 D
0EA6  4809 CC40 8B00 00F0          B R = B                                                                  04856000 D
0EA7  2F5C 00C0 0000 0060          EOUTPUT - 1 = CPCR         * WRITE NEW (R(A+1))                          04857000 D
```

```
0EA8  4809 0000 0000 20F0              ASR                      % REF BR1
0EA9  4809 0F40 8C1C C0FC              BMAR R = MAR2
0EAA  0000 0000 0000 0010              B = SAR
0EAB  4809 0C40 0030 00FC              B = MIR
0EAC  2F50 0000 0000 C060              EOUTPUT - 1 = CPCR       % WRITE NEW (R(A))
0EAD  66E0 0000 0000 0040              OPCODE - 1 = MPCR
                                                                %
                                                                %
                             OP233:                             % TYPE RX ADD DOUBLE, (R(A),R(A+1)) +
                                                                % (Y,Y+1) INTO R(A),R(A+1)
                                                                % SET CC, CARRY AND OV BITS
0EAE  5700 0000 0000 0060              RXMFIELD - 1 = CPCR      % ADDR OF Y INTO B
0EAF  4809 CC41 0010 00F0              B L = BR2
0EB0  0000 0000 0000 003C              COMP 8 = SAR
0EB1  60E0 0000 0000 006C              EMULIN - 1 = CPCR        % (Y) INTO B
0EB2  4809 CC41 2000 00F0              B L = A2                 % (Y) INTO MS WORD OF A2
0EB3  0000 0000 0000 0020              COMP 16 = SAR
0EB4  4809 0F47 0010 00F0              BMAR + 1 L = BR2
0EB5  0000 0000 0000 C030              COMP 8 = SAR
0EB6  60E0 0000 0000 C060              EMULIN - 1 = CPCR        % (Y+1) INTO B
0EB7  4809 CC5C 0C30 00F0              A2 OR B = MIR            % MIR = (Y)/(Y+1)
0EB8  4809 E000 8B00 00F0              A3 R = B
0EB9  80FC 0000 C00C 0000              4 = SAR; 15 = LIT
0EBA  4809 2C55 CB00 00F0              LIT AND B = B
0EBB  51C0 0000 C000 C06C              REGSTACK - 1 = CPCR
0EBC  4809 0F41 0C2C C0F0              BMAR L = BR1             % TEMP STORAGE OF R(A)
0EBD  0000 C0C0 0C00 0030              COMP 8 = SAR
0EBE  2F30 0000 0000 0060              EINPUT - 1 = CPCR        % (R(A)) INTO B
0EBF  4809 CC41 2000 00FC              B L = A2                 % (R(A)) INTO MS WORD OF A2
0EC0  0010 0000 0000 C0A0              COMP 16 = SAR;1 = LIT
0EC1  4809 2F5C 001C C0F0              LIT OR BMAR = MAR2       % R(A+1)
0EC2  2F3C 0000 000C 0060              EINPUT - 1 = CPCR        % (R(A+1)) INTO B
0EC3  4809 CC5C 2D0C 00F0              A2 OR B = A2, BMI        % A2 = (R(A))/(R(A+1))
0EC4  4809 CC40 0030 C0F0              A2 + B = MIR             % PERFORM THE ADDITION
0EC5  7DC9 0000 0C00 00F0              IF AOV THEN SET LC1
0EC6  1E7C 0000 000C C060              CARRY - 1 = CPCR
0EC7  4F10 0000 0C0C 006C              CHECKOV - 1 = CPCR
0EC8  49C9 C0C0 0D0C C0F0              BMI; SET LC1
0EC9  20DC 0000 0C0C 006C              SETCCA - 1 = CPCR        % SET THE CONDITION BITS
0ECA  4809 0000 CD00 00F0              BMI
0ECB  4809 CC41 200C 0CF0              B L = A2
0ECC  000C C0C0 0000 C02C              COMP 16 = SAR
0ECD  4809 CC40 8B00 00F0              B R = B
0ECE  4809 C0C0 8C90 C0F0              A2 R = MIR               % (R(A+1))
0ECF  2F5C 0000 0000 0060              EOUTPUT - 1 = CPCR       % WRITE NEW (R(A+1))
0ED0  4809 0000 000C 20FC              ASR                      % REF BR1
0ED1  4809 0F40 8C1C 00F0              BMAR R = MAR2
0ED2  000C 0000 0C00 C010              B = SAR
0ED3  4809 0C40 0030 C0F0              B = MIR                  % (R(A))
0ED4  2F50 0000 0000 C060              EOUTPUT - 1 = CPCR
0ED5  66E0 0000 0030 004C              OPCODE - 1 = MPCR
                                                                %
                                                                %
0ED6  5F90 0000 0000 0060    OPCODE24:  XFCODE - 1 = CPCR       % "F" INTO A2
0ED7  4809 C640 0C3C 00FC              A2 + AMPCR = AMPCR
0ED8  17BC 0000 0000 C0C0              OP24F - 1 = AMPCR
0ED9  4809 0000 000C 0CF0              STEP
0EDA  4824 C0C0 000C 00F0              EXEC
                                                                %
0EDB  17C0 0000 000C 0040    OP24F:    OP240 - 1 = MPCR
```

```
0EDC  1700 0000 0000 0040          OP241 - 1 = MPCR                                              04918000 D
0EDD  17EC 0000 0000 0040          OP242 - 1 = MPCR                                              04919000 D
0EDE  17F0 0000 0000 0040          OP243 - 1 = MPCR                                              04920000 D
                                                             %                                   04921000 D
                              OP240:                         % TYPE RR COMPARE, (R(A)):(R(M))    04922000 D
                                                             % SET CC, CARRY AND OV BITS         04923000 D
0EDF  2380 0000 0000 0060          CONTENTSRM - 1 = CPCR     % (R(M)) INTO B                     04924000 D
0EE0  4809 0C40 0090 00F0          B = MIR                   % TEMP STORAGE OF (R(M))            04925000 D
0EE1  4809 E000 0B00 00F0          A3 = B                                                        04926000 D
0EE2  22BC 0000 0000 0060          CONTENTSRA - 1 = CPCR     % (R(A)) INTO B                     04927000 D
0EE3  4809 0C41 2000 00F0          B L = A2, BMI                                                 04928000 D
0EE4  0000 0000 0000 0020          COMP 16 = SAR                                                 04929000 D
0EE5  4809 0C41 0B30 00F0          B L = B, MIR              % (R(M)) INTO MS WORD OF B, MIR     04930000 D
0EE6  2000 0000 0000 0060          SETCC - 1 = CPCR          % SET THE CONDITION BITS            04931000 D
0EE7  4809 0000 0D00 00F0          BMI                                                           04932000 D
0EE8  4849 0C5E 0090 00F0          A2 - B = MIR; SET LC2                                         04933000 D
0EE9  7BC9 0000 0000 00F0          IF AOV THEN SET LC1                                           04934000 D
0EEA  1E7C 0000 0000 0060          CARRY - 1 = CPCR                                              04935000 D
0EEB  4F10 0000 0000 0060          CHECKOV - 1 = CPCR                                            04936000 D
0EEC  66EC 0000 0000 0040          OPCODE - 1 = MPCR                                             04937000 D
                                                             %                                   04938000 D
                                                             %                                   04939000 D
                              OP241:                         % RI TYPE 2 COMPARE, (R(A)):(Y*)    04940000 D
                                                             % SET CC, CARRY AND OV BITS         04941000 D
0EED  22BC 0000 0000 0060          CONTENTSRA - 1 = CPCR     % (R(A)) INTO B                     04942000 D
0EEE  4809 0C40 0090 00F0          B = MIR                   % TEMP STORAGE OF (R(A))            04943000 D
0EEF  2380 0000 0000 0060          CONTENTSRM - 1 = CPCR     % (R(M)) INTO B                     04944000 D
0EF0  4809 0C41 0D10 00F0          B L = BR2, BMI                                                04945000 D
0EF1  0000 0000 0000 0030          COMP 8 = SAR                                                  04946000 D
0EF2  4809 0C41 2000 00F0          B L = A2                  % (R(A)) INTO A2                    04947000 D
0EF3  0000 0000 0000 0020          COMP 16 = SAR                                                 04948000 D
0EF4  6CE0 0000 0000 0060          EMULIN - 1 = CPCR         % (Y*) INTO B                       04949000 D
0EF5  4809 0C41 0B30 00F0          B L = B, MIR              % (Y*) INTO MS WORD OF B , MIR      04950000 D
0EF6  0000 0000 0000 0020          COMP 16 = SAR                                                 04951000 D
0EF7  2000 0000 0000 0060          SETCC - 1 = CPCR          % SET THE CONDITION BITS            04952000 D
0EF8  4809 0000 0D00 00F0          BMI                       % (Y*) BACK INTO D                  04953000 D
0EF9  4849 0C5E 0090 00F0          A2 - B = MIR; SET LC2                                         04954000 D
0EFA  7BC9 0000 0000 00F0          IF AOV THEN SET LC1                                           04955000 D
0EFB  1E7C 0000 0000 0060          CARRY - 1 = CPCR                                              04956000 D
0EFC  4F10 0000 0000 0060          CHECKOV - 1 = CPCR                                            04957000 D
0EFD  66E0 0000 0000 0040          OPCODE - 1 = MPCR                                             04958000 D
                                                             %                                   04959000 D
                                                             %                                   04960000 D
                              OP242:                         % TYPE RK COMPARE, (R(A)):Y         04961000 D
                                                             % SET CC, CARRY AND OV BITS         04962000 D
0EFE  4809 2C55 0B00 00F0          LIT AND B = B                                                 04963000 D
0EFF  00F0 0000 0000 00E0          15 = LIT                                                      04964000 D
0F00  4809 0C52 0000 00F0          0 EQL B                                                       04965000 D
0F01  6819 0000 0070 00F0          IF TRUE THEN SKIP                                             04966000 D
0F02  2380 0000 0000 0060          CONTENTSRM - 1 = CPCR     % (R(M)) INTO B                     04967000 D
0F03  4809 0C41 0B00 00F0          B L = B                                                       04968000 D
0F04  0000 0000 0000 0020          COMP 16 = SAR                                                 04969000 D
0F05  4809 EC5C 1C0C 00F0          A3 OR B = A3              % A3 = (R(M))/INSTRUCTION           04970000 D
0F06  5330 0000 0000 0060          IFETCH - 1 = CPCR         % "Y" INTO B                        04971000 D
0F07  4809 E000 A000 00F0          A3 R = A2                 % (R(M)) INTO A2                    04972000 D
0F08  0000 0000 0000 0020          16 = SAR                                                      04973000 D
0F09  4809 0C41 0C30 00F0          A2 + B L = MIR            % Y INTO MS WORD OF MIR             04974000 D
0F0A  4809 E000 0B00 00F0          A3 = B                                                        04975000 D
0F0B  22BC 0000 0000 0060          CONTENTSRA - 1 = CPCR     % (R(A)) INTO B                     04976000 D
0F0C  4809 0C41 2000 00F0          B L = A2, BMI             % (R(A)) INTO MS WORD OF A2         04977000 D
```

```
0F0D  0000 0000 0000 002C            COMP 16 = SAR
0F0E  4809 0C40 0030 00F0            0 = MIR
0F0F  200C 0000 0030 006C            SETCC - 1 = CPCR       * SET THE CONDITION BITS
0F10  4809 0000 0000 00F0            BMI
0F11  4849 CC5E 0080 00F0            A2 - B = MIR; SET LC2
0F12  7BC9 C000 003C C0F0            IF AOV THEN SET LC1
0F13  1E7C 0000 0000 0060            CARRY - 1 = CPCR
0F14  4F1C 0000 0030 0060            CHECKOV - 1 = CPCR
0F15  66E0 0000 000C 0040            OPCODE - 1 = MPCR
                                                            *
                                                            *
                           OP243:                           * RX TYPE COMPARE, (R(A)):Y
                                                            * SET CC, CARRY, AND OV BITS
0F16  570C 0000 000C 0060            RXMFIELD - 1 = CPCR    * Y INTO B
0F17  4809 0C41 0C10 00F0            B L = BR2
0F18  000C 0000 003C 003C            COMP 8 = SAR
0F19  60EC 0000 003C C060            EMULIN - 1 = CPCR      * (Y) INTO B
0F1A  4809 0C41 003C C0F0            B L = MIR
0F1B  000C C000 0030 C02C            COMP 16 = SAR
0F1C  4809 E000 0B00 C0FC            A3 = B
0F1D  2280 0000 0C00 006C            CONTENTSRA - 1 = CPCR  * (R(A)) INTO B
0F1E  4809 0C41 2030 00F0            B L = A2, BMI
0F1F  000C 0000 003C C020            COMP 16 = SAR
0F20  4809 0C40 003C C0F0            B = MIR
0F21  200C 0000 CC3C 0060            SETCC - 1 = CPCR
0F22  4809 0000 0000 C0F0            BMI
0F23  4849 CC5E 003C 00F0            A2 - B = MIR; SET LC2
0F24  7BC9 0C00 0C00 C0FC            IF AOV THEN SET LC1
0F25  1E7C 0000 003C 0060            CARRY - 1 = CPCR
0F26  4F1C C0C0 003C C060            CHECKOV - 1 = CPCR
0F27  66EC 0000 0C0C C040            OPCODE - 1 = MPCR
                                                            *
                                                            *
0F28  5F9C 0000 0C30 0060  OPCODE25:  XFCODE - 1 = CPCR     * "F" INTO A2
0F29  4809 C640 0040 00F0            A2 + AMPCR = AMPCR
0F2A  1800 0000 0CC0 00CC            OP25F - 1 = AMPCR
0F2B  4809 0000 0C3C C0F0            STEP
0F2C  4824 0000 0C00 C0F0            EXEC
                                                            *
0F2D  1810 0000 003C 0040  OP25F:    OP250 - 1 = MPCR
0F2E  182C 0000 0C00 0040            OP251 - 1 = MPCR
0F2F  3000 0000 003C 0040            FAULT - 1 = MPCR
0F30  183C 0000 000C C040            OP253 - 1 = MPCR
                                                            *
                           OP250:                           * TYPE RR COMPARE DOUBLE REGISTER
                                                            * (R(A),R(A+1)) : (R(M),R(M+1)),
                                                            * SET CARRY, CC, AND OV BITS
0F31  4809 0C40 8BC0 C0F0            B R = B
0F32  80FC 0000 0C00 C08C            15 = LIT; 4 = SAR
0F33  4809 2C56 0B3C C0F0            LIT AND B = B          * ISOLATE "A" FIELD
0F34  51CC C0C0 C03C 006C            REGSTACK - 1 = CPCR
0F35  2F3C C000 CC0C C06C            EINPUT - 1 = CPCR      * (R(A)) INTO B
0F36  4809 CC41 2030 00F0            B L = A2
0F37  001C C000 0C3C 00A0            COMP 16 = SAR;1 = LIT
0F38  4809 2F5C CC1C C0FC            LIT OR BMAR = MAR2     * R(A+1)
0F39  2F30 0000 0C0C C060            EINPUT - 1 = CPCR      * (R(A+1)) INTO B
0F3A  4809 CC5C 2030 00F0            A2 OR B = A2           * A2 = (R(A))/(R(A+1))
0F3B  4809 ECC0 0B30 C0FC            A3 = B
0F3C  4809 2C56 0B0C 00F0            LIT AND B = B          * ISOLATE "M" FIELD
0F3D  00FC 0000 0C00 C0E0            15 = LIT
```

```
0F3E  51C0 0000 0000 0060              REGSTACK - 1 = CPCR                                       05038000 D
0F3F  2F3C 0000 0000 0060              EINPUT - 1 = CPCR      % (R(M)) INTO B                    05039000 D
0F40  4809 0C41 1000 00F0              B L = A3                                                  05040000 D
0F41  0010 0000 0000 00A0              COMP 16 = SAR; 1 = LIT                                    05041000 D
0F42  4809 2F5C 001C 00F0              LIT OR BMAR = MAR2     % ADDR OF R(M+1)                   05042000 D
0F43  2F3C 0000 0000 0060              EINPUT - 1 = CPCR      % (R(M+1)) INTO B                  05043000 D
0F44  4809 EC5C CB90 00F0              A3 OR B = B, MIR       % B = (R(M))/(R(M+1))              05044000 D
0F45  20C0 0000 0000 0060              SETCC - 1 = CPCR                                          05045000 D
0F46  4809 0000 0D00 00F0              BMI                                                       05046000 D
0F47  4849 CC5E 0080 C0F0              A2 - B = MIR; SET LC2                                     05047000 D
0F48  7BC9 0000 0000 00F0              IF AOV THEN SET LC1                                       05048000 D
0F49  1E70 0000 0000 0060              CARRY - 1 = CPCR                                          05049000 D
0F4A  4F10 0000 0000 0060              CHECKOV - 1 = CPCR                                        05050000 D
0F4B  66E0 0000 0000 C040              OPCODE - 1 = MPCR                                         05051000 D
                                                              %                                  05052000 D
                                                              %                                  05053000 D
                             OP251:                           % RI TYPE 2 COMPARE DOUBLE         05054000 D
                                                              % (R(A),R(A+1)):(Y*,Y*+1)          05055000 D
                                                              % SET CC, CARRY, AND OV BITS       05056000 D
0F4C  4809 0C40 8B00 00F0              B R = B                                                   05057000 D
0F4D  90FC 0000 0000 0080              4 = SAR; 15 = LIT                                         05058000 D
0F4E  4809 2C56 CB00 C0F0              LIT AND B = B          % ISOLATE "A" FIELD                05059000 D
0F4F  51C0 0000 0000 0060              REGSTACK - 1 = CPCR                                       05060000 D
0F50  2F3C 0000 0000 0060              EINPUT - 1 = CPCR      % (R(A)) INTO B                    05061000 D
0F51  4809 0C41 2000 00F0              B L = A2               % (R(A)) INTO MS WORD OF A2        05062000 D
0F52  0010 0000 C000 00A0              COMP 16 = SAR ; 1 = LIT                                   05063000 D
0F53  4809 2F5C 001C 00F0              LIT OR BMAR = MAR2     % R(A+1)                           05064000 D
0F54  2F3C 0000 0000 0060              EINPUT - 1 = CPCR      % (R(A+1)) INTO B                  05065000 D
0F55  4809 CC5C 2000 00F0              A2 OR B = A2           % A2 = (R(A))/(RA+1))              05066000 D
0F56  4809 E156 CB00 C0FC              A3 AND LIT = B         % ISOLATE "M" FIELD                05067000 D
0F57  00F0 0000 0000 00E0              15 = LIT                                                  05068000 D
0F58  51C0 0000 0000 C060              REGSTACK - 1 = CPCR                                       05069000 D
0F59  4809 0F41 0010 00FC              BMAR L = BR2                                              05070000 D
0F5A  0000 0000 0000 003C              COMP 8 = SAR                                              05071000 D
0F5B  50E0 0000 0000 0060              EMULIN - 1 = CPCR      % (Y*) INTO B                      05072000 D
0F5C  4809 0C41 1000 00F0              B L = A3               % (Y*) INTO MS WORD OF A3          05073000 D
0F5D  0010 0000 0000 C0A0              COMP 16 = SAR ; 1 = LIT                                   05074000 D
0F5E  4809 2F5D 001C 00F0              LIT OR BMAR L = MAR2   % ADDR OF Y* + 1                   05075000 D
0F5F  000C 0000 0000 C03C              COMP 8 = SAR                                              05076000 D
0F60  60E0 0000 0000 C060              EMULIN - 1 = CPCR      % (Y*+1) INTO B                    05077000 D
0F61  4809 EC5C 0B50 00F0              A3 OR B = B, MIR       % B = (Y*)/(Y*+1)                  05078000 D
0F62  20C0 0000 0000 C06C              SETCC - 1 = CPCR       % SET THE CONDITION BITS           05079000 D
0F63  4809 C000 0D00 00F0              BMI                                                       05080000 D
0F64  4849 CC5E 0080 00F0              A2 - B = MIR; SET LC2                                     05081000 D
0F65  7BC9 0000 0000 00F0              IF AOV THEN SET LC1                                       05082000 D
0F66  1E7C C000 0000 C06C              CARRY - 1 = CPCR                                          05083000 D
0F67  4F1C 0000 0000 C06C              CHECKOV - 1 = CPCR                                        05084000 D
0F68  66E0 0000 C000 C040              OPCODE - 1 = MPCR                                         05085000 D
                                                              %                                  05086000 D
                                                              %                                  05087000 D
                             OP253:                           % TYPE RX DOUBLE COMPARE           05088000 D
                                                              %(R(A),R(A+1)):(Y,Y+1)             05089000 D
                                                              % SET CC, CARRY AND OV BITS        05090000 D
0F69  5700 0000 0000 006C              RXMFIELD - 1 = CPCR     % Y INTO E                        05091000 D
0F6A  4809 0C41 0010 00FC              D L = BR2                                                 05092000 D
0F6B  000C 0000 0000 C030              COMP 8 = SAR                                              05093000 D
0F6C  60E0 0000 0000 006C              EMULIN - 1 = CPCR      % (Y) INTO B                       05094000 D
0F6D  4809 CC41 2000 C0F0              B L = A2               % (Y) INTO MS WORD OF A2           05095000 D
0F6E  0010 0000 0000 00A0              COMP 16 = SAR ; 1 = LIT                                   05096000 D
0F6F  4809 2F5D 0010 C0F0              LIT OR BMAR L = BR2    % ADDR OF Y+1                      05097000 D
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0F70  0000 0000 0000 0030          COMP 8 = SAR
0F71  60E0 0000 0000 0060          EMULIN - 1 = CPCR       % (Y+1) INTO B
0F72  4809 CC5C 0080 00F0          A2 OR B = MIR           % MIR = (Y)/(Y+1)
0F73  4809 E000 9000 C0F0          A3 R = A3
0F74  30F0 0000 0000 C08C          4 = SAR; 15 = LIT
0F75  4809 E156 0D00 00F0          A3 AND LIT = B          % ISOLATE "A"
0F76  51C0 C000 0000 C060          REGSTACK - 1 = CPCR
0F77  2F30 0000 0000 C060          EINPUT - 1 = CPCR       % (R(A)) INTO B
0F78  4809 0C41 2000 00F0          B L = A2                % (R(A)) INTO MS WORD OF A2
0F79  0010 0000 0000 C0AC          COMP 16 = SAR ; 1 = LIT
0F7A  4809 2F5C C01C C0FC          LIT OR BMAR = MAR2      % R(A+1)
0F7B  2F30 0000 0000 C06C          EINPUT - 1 = CPCR       % (R(A+1)) INTO B
0F7C  4809 CC5C 2D0C 00F0          A2 OR B = A2, DMI       % A2 = (R(A))/(R(A+1))
0F7D  2000 0000 0000 C060          SETCC - 1 = CPCR        % SET THE CONDITION BITS
0F7E  4809 C0C0 CD00 00F0          BMI
0F7F  4849 CC5E 0090 00FC          A2 - D = MIR; SET LC2
0F80  7BC9 00C0 0000 00F0          IF ADV THEN SET LC1
0F81  1E7C 0C00 CC0C 0060          CARRY - 1 = CPCR
0F82  4F1C C0C0 0C0C C06C          CHECKOV - 1 = CPCR
0F83  66EC C000 0C0C 0040          OPCODE - 1 = MPCR
                                                           %
                                                           %
0F84  5F9C 0C00 0070 0060  OPCODE26:  XFCODE - 1 = CPCR    % "F" INTO A2
0F85  4809 C640 C040 00F0          A2 + AMPCR = AMPCR
0F86  184C C0C0 C00C 00C0          OP26F - 1 = AMPCR
0F87  4809 C0C0 0000 C0F0          STEP
0F88  4824 C000 0000 C0F0          EXEC
                                                           %
0F89  1850 0000 0600 0040  OP26F:  OP260 - 1 = MPCR
0F8A  1860 C0C0 0C00 0040          OP261 - 1 = MPCR
0F8B  187C 0CC0 0C00 0040          OP262 - 1 = MPCR
0F8C  1880 0000 0C0C C040          OP263 - 1 = MPCR
                                                           %
                                                           %
                           OP260:                          % RR TYPE MULTIPLY (REGISTER)
                                                           % (R(A+1)) X (R(M)) = R(A),R(A+1), SET CC
0F8D  4809 0C40 8B00 00F0          B R = B
0F8E  80FC 0000 0000 C08C          4 = SAR; 15 = LIT
0F8F  4809 2C56 0B00 00FC          LIT AND B = B           % ISOLATE "A"
0F90  51CC C0C0 0C0C 006C          REGSTACK - 1 = CPCR
0F91  4809 0F41 C020 0CF0          BMAR L = BR1            % TEMP STORAGE
0F92  000C 0000 0C00 0C30          COMP 8 = SAR
0F93  4809 0F45 0B0C C0FC          BMAR + 1 = B            % R(A+1)
0F94  51CC 0000 0C00 006C          REGSTACK - 1 = CPCR     % R(A+1) INTO MAR2
0F95  2F3C 0000 0C00 C06C          EINPUT - 1 = CPCR       % (R(A+1)) INTO B
0F96  4809 0C40 2C0C 00F0          B = A2
0F97  4809 E155 0B0C 00FC          A3 AND LIT = B          % ISOLATE "M"
0F98  00FC 0CC0 C00C 00L0          15 = LIT
0F99  51CC 0000 CC00 C060          REGSTACK - 1 = CPCR     % R(M) INTO MAR2
0F9A  2F30 0CC0 0030 0060          EINPUT - 1 = CPCR       % (R(M)) INTO B
0F9B  4C6C C0C0 0C0C C060          MULT - 1 = CPCR         % MULT (R(A+1)) X (R(M))
0F9C  4809 E0C0 0B0C C0FC          A3 = B                  % PRODUCT IN A3
0F9D  200C C0C0 CC0C 006C          SETCCA - 1 = CPCR       % SET THE CONDITION BITS
0F9E  48C9 E000 8C30 00FC          A3 R = MIR              % (R(A))
0F9F  000C C0C0 0000 C020          16 = SAR
0FA0  4809 0000 0000 20F0          ASR                     % REF BR1
0FA1  4809 0F40 801C C0FC          BMAR R = MAR2           % R(A)
0FA2  0C0C 0000 0000 C010          B = SAR
0FA3  2F5C C000 0C0C 0060          COUTPUT - 1 = CPCR
0FA4  4809 CF46 0B0C C0FC          BMAR + 1 = D            % R(A+1)
```

```
0FA5  51C0 0000 0000 0060             REGSTACK - 1 = CPCR     % R(A+1) INTO MAR2
0FA6  4809 EC01 100C 00F0             A3 L = A3
0FA7  0000 00C0 CC0C 0020             COMP 16 = SAR
0FA8  4809 EC00 8030 C0F0             A3 R = MIR
0FA9  2F50 0000 0000 0060             EOUTPUT - 1 = CPCR
0FAA  66E0 0000 0000 0040             OPCODE - 1 = MPCR
                                                              %
                                                              %
                            OP261:                            % RI TYPE 2 MULTIPLY (INDIRECT)
                                                              % (R(A+1)) X (Y*) = R(A),R(A+1), SET CC
0FAB  4809 CC40 8B00 C0F0             B R = B
0FAC  8CFC C0C0 0000 008C             4 = SAR; 15 = LIT
0FAD  48C9 2C55 0B00 00F0             LIT AND B = B           % ISOLATE "A"
0FAE  51C0 C000 C000 006C             REGSTACK - 1 = CPCR
0FAF  4809 0F41 002C C0F0             BMAR L = BR1            % R(A)
0FB0  00C0 0000 C000 003C             COMP 8 = SAR
0FB1  4809 0F46 0E00 C0F0             BMAR + 1 = B            % R(A+1)
0FB2  51CC 0000 C000 0060             REGSTACK - 1 = CPCR     % R(A+1) INTO MAR2
0FB3  2F30 0000 C000 0060             EINPUT - 1 = CPCR       % (R(A+1)) INTO B
0FB4  48C9 0C40 2000 00F0             B = A2                  % (R(A+1)) INTO A2
0FB5  4809 E156 0B00 C0F0             A3 AND LIT = B          % ISOLATE "M"
0FB6  00F0 00C0 C000 C0E0             15 = LIT
0FB7  51C0 0000 0C00 C060             REGSTACK - 1 = CPCR     % R(M) INTO MAR2
0FB8  2F30 C0C0 0000 C060             EINPUT - 1 = CPCR       % Y* INTO B
0FB9  4809 0C41 0010 C0F0             B L = BR2
0FBA  0000 0000 0000 0030             COMP 8 = SAR
0FBB  60EC 0000 C000 C060             EMULIN - 1 = CPCR       % (Y*) INTO B
0FBC  4C6C 0000 000C C060             MULT - 1 = CPCR         % MULT (R(A+1)) X (Y*)
0FBD  48C9 E000 0B00 C0FC             A3 = B                  % PRODUCT IN A3
0FBE  2000 00C0 0C0C 0060             SETCCA - 1 = CPCR       % SET THE CONDITION BITS
0FBF  4809 EC00 8C30 C0F0             A3 R = MIR              % (R(A))
0FC0  0000 0C00 000C C020             16 = SAR
0FC1  4809 0000 0000 20FC             ASR                     % REF ER1
0FC2  4809 0F40 801C 0CF0             BMAR R = MAR2           % R(A)
0FC3  000C 0CC0 0C0C 0010             8 = SAR
0FC4  2F5C 0000 0C00 C06C             EOUTPUT - 1 = CPCR
0FC5  4809 0F46 0B0C 00F0             BMAR + 1 = B            % R(A+1)
0FC6  51C0 00C0 000C 0060             REGSTACK - 1 = CPCR     % R(A+1) INTO MAR2
0FC7  4809 ED01 1000 00FC             A3 L = A3
0FC8  000C 0000 0C0C 002C             COMP 16 = SAR
0FC9  4809 ECC0 803C C0F0             A3 R = MIR
0FCA  2F5C 0000 0C0C C060             EOUTPUT - 1 = CPCR
0FCB  66EC C0C0 0C0C C040             OPCODE - 1 = MPCR
                                                              %
                                                              %
                            OP262:                            % TYPE RK MULTIPLY (CONSTANT)
                                                              % (R(A+1)) X Y = R(A),R(A+1), SET CC
0FCC  4809 2C56 CB00 00F0             LIT AND B = B           % ISOLATE "M"
0FCD  0CFC 0000 C00C C0EC             15 = LIT
0FCE  48C9 0C52 0030 C0F0             0 EQL B                 % CHECK FOR M = 0
0FCF  6819 C000 0C00 C0F0             IF TRUE THEN SKIP
0FD0  238C 0000 000C CC60             CONTENTSRM - 1 = CPCR   % (R(M)) INTO B
0FD1  4809 0C41 0B00 00F0             B L = B
0FD2  00CC 00C0 C000 C02C             COMP 16 = SAR
0FD3  4809 EC5C 1C0C C0F0             A3 OR B = A3            % A3 = (R(M))/INSTRUCTION
0FD4  6330 0000 0C00 C060             IFETCH - 1 = CPCR       % "Y" INTO B
0FD5  4809 EC00 A000 00F0             A3 R = A2               % (R(M)) INTO A2
0FD6  000C C000 000C CC2C             16 = SAR
0FD7  4809 CC40 2000 C0FC             A2 + B = A2             % Y INTO B
0FD8  4809 E0C0 8B00 00F0             A3 R = B
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0FD9  9CFC 0000 C0DC 0080              4 = SAR; 15 = LIT
0FDA  4809 2C56 0B00 00F0              LIT AND B = B          % ISOLATE "A"               05219000 D
0FDB  51CC 0000 0000 0060              REGSTACK - 1 = CPCR                                05220000 D
0FDC  4809 0F41 0020 C0F0              BMAR L = BR1           % R(A)                      05221000 D
0FDD  000C 0C00 0000 0030              COMP 8 = SAR                                       05222000 D
0FDE  4809 0F46 0B00 00FC              BMAR + 1 = B           % R(A+1)                    05223000 D
0FDF  51CC 0000 0000 0060              REGSTACK - 1 = CPCR    % R(A+1) INTO MAR2          05224000 D
0FE0  2F3C 0000 0C00 C06C              EINPUT - 1 = CPCR      % (R(A+1)) INTO B           05225000 D
0FE1  4C60 C0C0 0000 0060              MULT - 1 = CPCR        % MULTIPLY (R(A+1)) X  Y    05226000 D
0FE2  48C9 E0C0 0B0C 00F0              A3 = B                 % PRODUCT IN A3             05227000 D
0FE3  2CDC 0CC0 0C00 006C              SETCCA - 1 = CPCR      % SET THE CONDITION BITS    05228000 D
0FE4  4809 E0C0 8C9C 00F0              A3 R = MIR             % (R(A))                    05229000 D
0FE5  0000 00C0 C000 0020              16 = SAR                                           05230000 D
0FE6  4809 0C00 0C00 20F0              ASR                    % REF BR1                   05231000 D
0FE7  4809 CF40 8C1C C0F0              BMAR R = MAR2          % R(A)                      05232000 D
0FE8  000C 0C00 0C00 001C              B = SAR                                            05233000 D
0FE9  2F5C CCC0 0000 C06D              EOUTPUT - 1 = CPCR                                 05234000 D
0FEA  4809 CF46 0B0C C0F0              BMAR + 1 = B           % R(A+1)                    05235000 D
0FEB  51CC 0000 0000 006D              REGSTACK - 1 = CPCR    % R(A+1) INTO MAR2          05236000 D
0FEC  4809 E001 1030 C0FC              A3 L = A3                                          05237000 D
0FED  0C0C 00C0 000C 0020              COMP 16 = SAR                                      05238000 D
0FEE  48C9 EC00 8030 00FD              A3 R = MIR                                         05239000 D
0FEF  2F50 C0C0 CC0C 0060              EOUTPUT - 1 = CPCR                                 05240000 D
0FF0  66E0 00C0 C000 004C              OPCODE - 1 = MPCR                                  05241000 D
                                                              %                           05242000 D
                                                              %                           05243000 D
                                 OP263:                       % RX TYPE MULTIPLY, (R(A+1)) X (Y) =   05244000 D
                                                              % R(A),R(A+1), AND SET CC   05245000 D
0FF1  5700 00C0 DC00 C060              RXMFIELD - 1 = CPCR    % Y INTO B                  05246000 D
0FF2  4809 CC41 CC1C C0F0              B L = BR2                                          05247000 D
0FF3  000C C0C0 0000 0030              COMP 8 = SAR                                       05248000 D
0FF4  60E0 00C0 0030 006C              EMULIN - 1 = CPCR      % (Y) INTO B                05249000 D
0FF5  48C9 0C40 0090 C0F0              B = MIR                                            05250000 D
0FF6  4809 E0C0 8B00 C0F0              A3 R = B                                           05251000 D
0FF7  80FC 0000 0C0C 008D              4 = SAR; 15 = LIT                                  05252000 D
0FF8  4809 2C56 0B00 00F0              LIT AND B = B          % ISOLATE "A"               05253000 D
0FF9  51CC 0000 0030 0060              REGSTACK - 1 = CPCR                                05254000 D
0FFA  4809 0F41 0020 C0FD              BMAR L = BR1           % SAVE R(A)                 05255000 D
0FFB  000C C000 0C00 0030              COMP 8 = SAR                                       05256000 D
0FFC  48C9 0F46 CB00 00FC              BMAR + 1 = B           % R(A+1)                    05257000 D
0FFD  51C0 0000 D000 C060              REGSTACK - 1 = CPCR    % R(A+1) INTO MAR2          05258000 D
0FFE  2F3C 00C0 0C00 006C              EINPUT - 1 = CPCR      % (R(A+1)) INTO B           05259000 D
0FFF  4809 0C40 2D00 C0F0              B = A2, BMI                                        05260000 D
1000  4C6C 00C0 0C00 C060              MULT - 1 = CPCR        % MULTIPLY (R(A+1)) X (Y)   05261000 D
1001  4809 E0C0 CB00 00F0              A3 = B                 % PRODUCT IN A3             05262000 D
1002  20DC 0CC0 0030 0060              SETCCA - 1 = CPCR      % SET THE CONDITION BITS    05263000 D
1003  4809 E0C0 8090 C0FD              A3 R = MIR             % (R(A))                    05264000 D
1004  0CCC C000 000C 0020              16 = SAR                                           05265000 D
1005  4609 C000 CC0C 20FC              ASR                    % REF BR1                   05266000 D
1006  4809 0F40 8C1C C0F0              BMAR R = MAR2          % R(A)                      05267000 D
1007  000C 00C0 000C 0C10              B = SAR                                            05268000 D
1008  2F5C 0C00 0000 006C              EOUTPUT - 1 = CPCR                                 05269000 D
1009  4809 0F46 0B00 C0FC              BMAR + 1 = B           % R(A+1)                    05270000 D
100A  51C0 00C0 0000 C06C              REGSTACK - 1 = CFCR    % R(A+1) INTO MAR2          05271000 D
100B  4809 E0C1 1000 00F0              A3 L = A3                                          05272000 D
100C  4809 E0C0 8C9C 00F0              A3 R = MIR                                         05273000 D
100D  2F5C 0000 C0C0 CC60              EOUTPUT - 1 = CPCR                                 05274000 D
100E  66EC C0C0 0C0C 0040              OPCODE - 1 = MPCR                                  05275000 D
                                                              %                           05276000 D
                                                              %                           05277000 D
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100F  5F90 0000 000C C060    OPCODE27:  XFCODE - 1 = CPCR      % "F" INTO A2                            05278000 D
1010  4809 C640 C040 00F0               A2 + AMPCR = AMPCR                                              05279000 D
1011  1890 0000 0000 C0C0               OP27F - 1 = AMPCR                                               05280000 D
1012  4809 0000 0000 00F0               STEP                                                            05281000 D
1013  4824 0000 0000 00F0               EXEC                                                            05282000 D
                                                               %                                        05283000 D
1014  18A0 0000 0000 C040    OP27F:     OP270 - 1 = MPCR                                                05284000 D
1015  18B0 0000 0000 C040               OP271 - 1 = MPCR                                                05285000 D
1016  18CC 0000 0000 C040               OP272 - 1 = MPCR                                                05286000 D
1017  18D0 0000 0000 C040               OP273 - 1 = MPCR                                                05287000 D
                                                               %                                        05288000 D
                                                               %                                        05289000 D
                             OP270:                            % TYPE RR DIVIDE (REGISTER)              05290000 D
                                                               % R(A),R(A+1)/(R(M)) = R(A+1), REMAINDER 05291000 D
                                                               % INTO R(A), SET CC AND OV               05292000 D
1018  4809 0C40 8000 00FC               B R = B                                                         05293000 D
1019  80F0 0000 0000 0080               4 = SAR; 15 = LIT                                               05294000 D
101A  4809 2C56 0B00 C0FC               LIT AND B = B          % ISOLATE "A"                            05295000 D
101B  51CC 0000 C000 0060               REGSTACK - 1 = CPCR                                             05296000 D
101C  4809 CF41 0C20 C0F0               BMAR L = BR1           % TEMP STORAGE                           05297000 D
101D  0C0C 0000 0000 C03C               COMP 8 = SAR                                                    05298000 D
101E  2F30 0000 0000 0060               EINPUT - 1 = CPCR      % (R(A)) INTO B                          05299000 D
101F  4809 0C41 2C00 00F0               B L = A2                                                        05300000 D
1020  000C 0CC0 0000 0020               COMP 16 = SAR                                                   05301000 D
1021  4809 CF46 0B00 00F0               BMAR + 1 = B           % R(A+1)                                 05302000 D
1022  51CC 0000 000C 0060               REGSTACK - 1 = CPCR    % R(A+1) INTO MAR2                       05303000 D
1023  2F30 0000 0000 C060               EINPUT - 1 = CPCR      % (R(A+1)) INTO B                        05304000 D
1024  4809 CC5C 2000 C0F0               A2 OR B = A2           % A2 = (R(A))/(R(A+1))                   05305000 D
1025  4809 E156 0B00 C0F0               A3 AND LIT = B         % ISOLATE "M"                            05306000 D
1026  00F0 0000 0000 00EC               15 = LIT                                                        05307000 D
1027  51CC 0000 000C C060               REGSTACK - 1 = CPCR                                             05308000 D
1028  2F30 0000 0C00 006C               EINPUT - 1 = CPCR      % (R(M)) INTO E                          05309000 D
1029  49C9 0C41 0B00 00F0               B L = B; SET LC1       % LEFT JUSTIFY (R(M)), SET 32 BIT FLAG   05310000 D
102A  000C 0000 0000 0020               COMP 16 = SAR                                                   05311000 D
102B  240C C000 0000 C060               DIV - 1 = CPCR         % (R(A),R(A+1))/(R(M))                   05312000 D
102C  20CB 00C0 000C 0CF0               IF LC1 THEN SET LC1; STEP ELSE SKIP  % CHECK FOR OVERFLOW       05313000 D
102D  50AC 0000 0000 0060               SETOVBIT - 1 = CPCR    % SET THE OV BIT                         05314000 D
102E  2819 00C0 C000 C0F0               IF LC1 THEN SKIP                                                05315000 D
102F  5050 0CC0 000C C060               CLEAROV - 1 = CPCR     % CLEAR THE OV BIT                       05316000 D
1030  4809 E000 0000 00F0               A3 = B                 % QUOTIENT INTO B                        05317000 D
1031  4809 C0C0 C030 00F0               A2 = MIR               % REMAINDER INTO MIR                     05318000 D
1032  200C 0000 0C0C C060               SETCCA - 1 = CPCR      % SET THE CONDITION BITS                 05319000 D
1033  4809 0C00 C000 20F0               ASR                    % REFERENCE BR1                          05320000 D
1034  4809 0F40 8C1C 00FC               BMAR R = MAR2          % R(A)                                   05321000 D
1035  0000 0000 0000 0010               B = SAR                                                         05322000 D
1036  2F50 0000 000C C060               EOUTPUT - 1 = CPCR     % REMAINDER IN R(A)                      05323000 D
1037  4809 0000 0C00 24F0               ASE                    % REFERENCE MAR2                         05324000 D
1038  4809 0F46 0B0C C0F0               BMAR + 1 = B           % CREATE R(A+1)                          05325000 D
1039  51CC C000 0000 C060               REGSTACK - 1 = CPCR    % R(A+1) INTO MAR2                       05326000 D
103A  4809 E000 0030 00F0               A3 = MIR               % QUOTIENT                               05327000 D
103B  2F5C 0000 000C 0060               EOUTPUT - 1 = CPCR                                              05328000 D
103C  66E0 0000 0000 0040               OPCODE - 1 = MPCR                                               05329000 D
                                                               %                                        05330000 D
                                                               %                                        05331000 D
                             OP271:                            % RI TYPE 2 DIVIDE (INDIRECT)            05332000 D
                                                               % (R(A),R(A+1))/(Y*) = R(A+1), REMAINDER 05333000 D
                                                               % INTO R(A), SET CC AND OV               05334000 D
103D  4809 0C40 8B0C C0F0               B R = B                                                         05335000 D
103E  80FC 0000 C000 0080               4 = SAR; 15 = LIT                                               05336000 D
103F  4809 2C56 0B00 C0F0               LIT AND B = B          % ISOLATE "A"                            05337000 D
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1040  51C0 00C0 C030 0060          REGSTACK - 1 = CPCR                                05338000 D
1041  4809 CF41 0020 C0F0          BMAR L = BR1          % TEMP STORAGE               05339000 D
1042  0C00 C0C0 0C00 C030          COMP 8 = SAR                                       05340000 D
1043  2F3C 00C0 0C00 0060          EINPUT - 1 = CPCR     % (R(A)) INTO B              05341000 D
1044  4809 0C41 2000 00FC          B L = A2                                           05342000 D
1045  000C 0000 0C00 C020          COMP 16 = SAR                                      05343000 D
1046  4809 0F46 0B00 00F0          BMAR + 1 = B          % R(A+1)                     05344000 D
1047  51CC 00C0 00C0 0060          REGSTACK - 1 = CPCR   % P(A+1) INTO MAR2           05345000 D
1048  2F3C 0CC0 0C0C C060          EINPUT - 1 = CPCR     % (R(A+1)) INTO B            05346000 D
1049  4809 CC5C 2000 00F0          A2 OR B = A2          % A2 =(R(A))/(R(A+1))        05347000 D
104A  4809 E156 0B00 00F0          A3 AND LIT = D        % ISOLATE "M"                05348000 D
104B  00F0 C0C0 000C 00E0          15 = LIT                                           05349000 D
104C  51CC C0C0 0C00 0060          REGSTACK - 1 = CPCR                                05350000 D
104D  2F30 00C0 0000 C060          EINPUT - 1 = CPCR     % Y* INTO B                  05351000 D
104E  4809 0C41 001C 0CF0          B L = BR2                                          05352000 D
104F  000C 0CC0 0000 C030          COMP 8 = SAR                                       05353000 D
1050  50E0 00C0 0C0C 0060          EMULIN - 1 = CPCR     % (Y*) INTO B                05354000 D
1051  49C9 0C41 0B0C 00F0          B L = B; SET LC1      % LEFT JUSTIFY (Y*)          05355000 D
1052  000C 00C0 0000 0020          COMP 16 = SAR                                      05356000 D
1053  240C 00C0 0C00 C060          DIV - 1 = CPCR        % (R(A),R(A+1))/(Y*)         05357000 D
1054  2BCB C0C0 0CC0 C0F0          IF LC1 THEN SET LC1; STEP ELSE SKIP  % CHECK FOR OVERFLOW  05358000 D
1055  50AC 0000 0C00 0C60          SETOVBIT - 1 = CPCR   % SET THE OV BIT             05359000 D
1056  2819 00C0 0C00 00FC          IF LC1 THEN SKIP                                   05360000 D
1057  5050 00C0 C00C 0060          CLEAROV - 1 = CPCR    % CLEAR THE OV BIT           05361000 D
1058  4809 CCC0 00BC 00FC          A2 = MIR              % REMAINDER INTO MIR         05362000 D
1059  4809 E0C0 0B0C 00FC          A3 = D                % QUOTIENT INTO B            05363000 D
105A  2000 0000 0C00 0060          SETCCA - 1 = CPCR     % SET THE CONDITION BITS     05364000 D
105B  4809 0CC0 0000 20FC          ASR                   % REF BR1                    05365000 D
105C  48C9 0F4D 8C1C C0F0          BMAR R = MAR2         % R(A)                       05366000 D
105D  D00C C000 000C C01C          B = SAR                                            05367000 D
105E  2F5C 0CC0 000C C06C          EOUTPUT - 1 = CPCR                                 05368000 D
105F  4809 E0C0 0C30 00F0          A3 = MIR                                           05369000 D
1060  48C9 0F46 0B0C 00F0          BMAR + 1 = B          % R(A+1)                     05370000 D
1061  51C0 C000 000C C060          REGSTACK - 1 = CPCR   % R(A+1) INTO MAR2           05371000 D
1062  2F5C C0C0 000C 006C          EOUTPUT - 1 = CPCR                                 05372000 D
1063  66EC 00C0 0C0C 0040          OPCODE - 1 = MPCR                                  05373000 D
                                                         %                            05374000 D
                                                         %                            05375000 D
                         OP272:                          % TYPE RK DIVIDE (CONSTANT)  05376000 D
                                                         % (R(A),R(A+1))/Y = R(A+1), REMAINDER  05377000 D
                                                         % INTO R(A), SET CC AND OV   05378000 D
1064  4809 E156 0B00 C0F0          A3 AND LIT = B        % ISOLATE "M"                05379000 D
1065  00FC 0000 C000 00E0          15 = LIT                                           05380000 D
1066  4809 CC52 0C0C 00F0          D EQL B               % CHECK FOR M = 0            05381000 D
1067  6819 C0C0 0C00 C0F0          IF TRUE THEN SKIP                                  05382000 D
1068  238C 00C0 0000 006C          CONTENTSRM - 1 = CPCR  % (R(M)) INTO B             05383000 D
1069  4809 0C41 0B0C 00FC          B L = B                                            05384000 D
106A  000C 0C00 0C0C CC20          COMP 16 = SAR                                      05385000 D
106B  48C9 EC5C 1000 00FC          A3 OR B = A3          % A3 = (R(M))/INSTRUCTION    05386000 D
106C  6330 0CC0 0C00 C060          IFETCH - 1 = CPCR     % "Y" INTO B                 05387000 D
106D  4809 E0C0 AC00 C0F0          A3 R = A2             % (R(M)) INTO A2             05388000 D
106E  0000 0CC0 0C30 C020          16 = SAR                                           05389000 D
106F  4809 CC41 0B0C 00FC          A2 + B L = B          % Y INTO MS WORD OF B        05390000 D
1070  4809 E0C1 1000 C0F0          A3 L = A3             % CLEAR UHW OF A3            05391000 D
1071  4809 E00D 9000 C0F0          A3 R = A3                                          05392000 D
1072  4809 EC5C 100C C0FC          A3 OR B = A3          % A3 = Y/INSTRUCTION         05393000 D
1073  4809 E0C0 8B00 00F0          A3 R = B                                           05394000 D
1074  90FC 00C0 000C 008C          4 = SAR; 15 = LIT                                  05395000 D
1075  4809 2C56 0B00 00F0          LIT AND B = B         % ISOLATE "A"                05396000 D
1076  51CC 000D C000 0060          REGSTACK - 1 = CPCR                                05397000 D
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1C77   4809 0F41 0020 00F0        BMAR L = OR1             % TEMP STORAGE                          05398000 D
1C78   000C 0C00 0C00 0C30        COMP 8 = SAR                                                     05399C00 D
1C79   2F30 00C0 0C00 0060        EINPUT - 1 = CPCR        % (R(A)) INTO E                         05400C00 D
1C7A   4809 0C41 2000 00F0        B L = A2                                                         05401C00 D
1C7B   0000 C000 CC00 C02C        COMP 16 = SAR                                                    05402C00 D
1C7C   4809 0F46 080C C0F0        BMAR + 1 = B             % R(A+1)                                05403000 D
1C7D   51CC 0000 CC00 0060        REGSTACK - 1 = CPCR      % R(A+1) INTO MAR2                      05404C00 D
1C7E   2F3C 00C0 0000 0060        EINPUT - 1 = CPCR        % (R(A+1)) INTO B                       05405C00 D
1C7F   4809 CC5C 2C00 C0F0        A2 OR B = A2             % A2 = (R(A))/(R(A+1))                  05406C00 D
1080   49C9 EC00 8800 00F0        A3 R = B; SET LC1        % Y INTO B                              05407C00 D
1C81   000C 0000 0000 0020        16 = SAR                                                         05408C00 D
1C82   4809 0C41 080C C0FC        B L = B                  % LEFT JUSTIFY DIVISOR                  05409C00 D
1C83   2400 00C0 0000 0060        DIV - 1 = CPCR           % (R(A),R(A+1))/Y                       05410000 D
1C84   28CB 0C00 0000 00F0        IF LC1 THEN SET LC1; STEP ELSE SKIP  % CHECK FOR OVERFLOW        05411C00 D
1085   50AC 0C0C C000 0060        SETOVBIT - 1 = CPCR      % SET THE OV BIT                        05412C00 D
1C86   2819 C0C0 C000 00F0        IF LC1 THEN SKIP                                                 05413C00 D
1C87   5050 C0C0 C0C0 0060        CLEAROV - 1 = CPCR       % CLEAR THE OV BIT                      05414C00 D
1C88   4809 EC00 080C C0FC        A3 = B                   % QUOTIENT FOR SET CC                   05415C0C D
1C89   260C C0C0 0C0C 0060        SETCCA - 1 = CPCR        % SET THE CONDITION BITS                05416C00 D
1C8A   4809 C0C0 0C30 20F0        A2 = MIR; ASR            % REMAINDER INTO MIR                    05417C00 D
1C8B   4809 0F40 8C1C C0FC        BMAR R = MAR2            % R(A)                                  05418C00 D
1C8C   000C 00C0 0C00 C010        6 = SAR                                                          05419C00 D
1C8D   2F5C 0C00 C00C 0060        EOUTPUT - 1 = CPCR                                               05420C00 D
1C8E   4809 0F46 0800 00FC        BMAR + 1 = B             % R(A+1)                                05421C0C D
1C8F   51CC 0000 0C00 0060        REGSTACK - 1 = CPCR      % R(A+1) INTO MAR2                      05422C00 D
1C90   4809 ECC0 0C30 00F0        A3 = MIR                 % QUOTIENT INTO MIR                     05423C0C D
1C91   2F50 C000 0C0C 0060        EOUTPUT - 1 = CPCR                                               05424C00 D
1C92   66EC 00C0 0000 0040        OPCODE - 1 = MPCR                                                05425C00 D
                                                           %                                       05426000 D
                                                           %                                       05427C00 D
                            OP273:                         % TYPE RX DIVIDE, (R(A),R(A+1))/(Y) =   05428C0C D
                                                           % R(A+1), REMAINDER INTO R(A), SET OV, CC05429C0C D
1093   570C 00C0 0000 0C60        RXMFIELD - 1 = CPCR      % Y INTO B                              05430C00 D
1C94   4809 0C41 0010 C0F0        B L = BR2                                                        05431000 D
1C95   000C C0C0 0C0C C030        COMP 8 = SAR                                                     05432C00 D
1C96   60E0 0CC0 0000 C060        EMULIN - 1 = CPCR        % (Y) INTO B                            05433C00 D
1C97   4809 CC40 0C30 C0F0        B = MIR                                                          05434C00 D
1C98   4809 E0C0 8800 00FC        A3 R = B                                                         05435C0C D
1C99   90FC 0000 0000 0080        4 = SAR; 15 = LIT                                                05436C00 D
1C9A   4809 2C56 080C 00FC        LIT AND B = B            % ISOLATE "A"                           05437C0C D
1C9B   51CC CCC0 CC0C C06C        REGSTACK - 1 = CPCR      % R(A) INTO MAR2                        05438000 D
1C9C   4809 CF41 002C 00F0        BMAR L = BR1             % TEMP STORAGE                          05439C00 D
1C9D   000C 0C00 0000 C030        COMP 8 = SAR                                                     05440C00 D
109E   2F3C 00C0 C000 0060        EINPUT - 1 = CPCR        % (R(A)) INTO E                         05441C0C D
1C9F   4809 0C41 2000 00FC        B L = A2                                                         05442C0C D
1CA0   0000 0000 CC00 0020        COMP 16 = SAR                                                    05443C00 D
1CA1   4809 0F46 080C 00F0        BMAR + 1 = B             % R(A+1)                                05444C00 D
1CA2   51CC 0000 CC00 0060        REGSTACK - 1 = CPCR      % R(A+1) INTO MAR2                      05445C00 D
1CA3   2F3C 0000 0000 C060        EINPUT - 1 = CPCR        % (R(A+1)) INTO B                       05446C00 D
1CA4   4809 CC5C 2000 C0FC        A2 OR B = A2             % A2 = (R(A))/(R(A+1))                  05447C00 D
1CA5   49C9 00C0 C00C 00F0        BMI; SET LC1                                                     05448C00 D
1CA6   4809 0C41 0800 00F0        B L = B                  % LEFT JUSTIFY THE DIVISOR              05449C00 D
1CA7   00CC 0000 0C0C 0020        COMP 16 = SAR                                                    05450C0C D
1CA8   240C 00C0 0C00 C060        DIV - 1 = CPCR           % (R(A),R(A+1))/(Y)                     05451C00 D
1CA9   28CB 0C00 C000 C0F0        IF LC1 THEN SET LC1; STEP ELSE SKIP  % CHECK FOR OVERFLOW        05452C0C D
1CAA   50AC 0C00 0C00 C060        SETOVBIT - 1 = CPCR      % SET THE OV BIT                        05453C00 D
1CAB   2819 0000 000C C0F0        IF LC1 THEN SKIP                                                 05454C00 D
1CAC   505C 00C0 C00C C060        CLEAROV - 1 = CPCR       % CLEAR THE OV BIT                      05455C0C D
1CAD   4809 E000 0800 C0FC        A3 = B                   % QUOTIENT INTO B                       05456000 D
1CAE   2000 0000 CC00 C060        SETCCA - 1 = CPCR        % SET THE CONDITION BITS                05457000 D
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1CAF  4809 C0C0 0090 20FC              A2 = MIR; ASR             % REMAINDER INTO MIR                   05458000 D
1CB0  4809 0F40 801C C0F0              BMAR R = MAR2             % R(A)                                 05459000 D
1CB1  0000 0000 0000 0010              B = SAR                                                          05460000 D
1CB2  2F50 00C0 0000 C060              EOUTPUT - 1 = CPCR        % QUOTIENT INTO R(A+1)                 05461000 D
1CB3  4809 0F46 0B00 C0F0              BMAR + 1 = B              % R(A+1)                               05462000 D
1CB4  51C0 0000 0000 0060              REGSTACK - 1 = CPCR       % R(A+1) INTO MAR2                     05463000 D
1CB5  4809 E000 0030 00FC              A3 = MIR                  % QUOTIENT INTO MIR                    05464000 D
1CB6  2F50 00C0 0000 C060              EOUTPUT - 1 = CPCR                                               05465000 D
1CB7  66E0 00C0 0000 C040              OPCODE - 1 = MPCR                                                05466000 D
                                                                 %                                      05467000 D
                                                                 %                                      05468000 D
1CB8  5F90 C0C0 0000 0C60  OPCODE30:  XFCODE - 1 = CPCR          % "F" INTO A2                          05469000 D
1CB9  4809 C640 0090 00F0              A2 + AMPCR = AMPCR                                               05470000 D
1CBA  18EC C000 0000 C0CC              OP30F - 1 = AMPCR                                                05471000 D
1CBB  4809 0000 0000 00FC              STEP                                                             05472000 D
1CBC  4824 0C00 0000 00FC              EXEC                                                             05473000 D
                                                                 %                                      05474000 D
1CBD  18FC 0000 C000 0040  OP30F:      OP300 - 1 = MPCR                                                 05475000 D
1CBE  190C 0000 0000 C040              OP301 - 1 = MPCR                                                 05476000 D
1CBF  191C 0C00 0000 004C              OP302 - 1 = MPCR                                                 05477000 D
1CC0  1920 00C0 0C00 0040              OP303 - 1 = MPCR                                                 05478000 D
                                                                 %                                      05479000 D
                                                                 %                                      05480000 D
                           OP300:                                % TYPE RR AND (REGISTER)               05481000 D
                                                                 % (R(A)) AND (R(M)) = R(A), SET CC     05482000 D
1CC1  22BC C000 0020 0060              CONTENTSRA - 1 = CPCR     % (R(A)) INTO B                        05483000 D
1CC2  4809 0C40 0C90 00FC              B = MIR                   % USED AS TEMP                         05484000 D
1CC3  2380 0000 0000 0060              CONTENTSRM - 1 = CPCR     % (R(M)) INTO B                        05485000 D
1CC4  4809 0C40 2D00 00F0              B = A2, BMI                                                      05486000 D
1CC5  4809 CC56 0B9C CGF0              A2 AND B = MIR, B                                                05487000 D
1CC6  4809 E000 801C C0F0              A3 R = MAR2               % R(A)                                 05488000 D
1CC7  0000 0000 0030 0020              16 = SAR                                                         05489000 D
1CC8  2F50 0000 0000 0C60              EOUTPUT - 1 = CPCR                                               05490000 D
1CC9  20DC 0000 0000 C060              SETCCA - 1 = CPCR         % SET THE CONDITION BITS               05491000 D
1CCA  66E0 C0C0 0000 0040              OPCODE - 1 = MPCR                                                05492000 D
                                                                 %                                      05493000 D
                                                                 %                                      05494000 D
                           OP301:                                % RI TYPE 2 AND (INDIRECT)             05495000 D
                                                                 % (R(A)) AND (Y*) = R(A), SET CC       05496000 D
1CCB  238C 00C0 0C90 C06C              CONTENTSRM - 1 = CPCR     % Y* INTO B                            05497000 D
1CCC  4809 CC41 001C C0F0              B L = BR2                                                        05498000 D
1CCD  0C0C 0CC0 0C20 C030              COMP B = SAR                                                     05499000 D
1CCE  6CEC 00C0 C0DC C060              EMULIN - 1 = CPCR         % (Y*) INTO B                          05500000 D
1CCF  4809 CC40 008C C0F0              B = MIR                                                          05501000 D
1CD0  4809 E000 0B00 CCF0              A3 = B                                                           05502000 D
1CD1  22BC 00C0 0C0C C060              CONTENTSRA - 1 = CPCR     % (R(A)) INTO B                        05503000 D
1CD2  4809 0C40 2D00 CCF0              B = A2,BMI                                                       05504000 D
1CD3  4809 CC56 0B90 00FC              A2 AND B = MIR, B                                                05505000 D
1CD4  2F5C 00C0 C00C 0060              EOUTPUT - 1 = CPCR                                               05506000 D
1CD5  20D0 CCC0 0C0C C060              SETCCA - 1 = CPCR         % SET THE CONDITION BITS               05507000 D
1CD6  56EC 00C0 0C30 0040              OPCODE - 1 = MPCR                                                05508000 D
                                                                 %                                      05509000 D
                                                                 %                                      05510000 D
                           OP302:                                % TYPE RK AND (CONSTANT)               05511000 D
                                                                 % (R(A)) AND Y = R(A), SET CC          05512000 D
1CD7  4809 2C56 0B0C 00F0              LIT AND B = B             % ISOLATE "M"                          05513000 D
1CD8  00FC C0C0 C00C C0EC              15 = LIT                                                         05514000 D
1CD9  4809 0C52 0000 0CFC              C EQL B                   % CHECK FOR M = 0                      05515000 D
1CDA  6819 00C0 0C00 00FC              IF TRUE THEN SKIP                                                05516000 D
1CDB  238C 0000 0C0C C06C              CONTENTSRM - 1 = CPCR     % (R(M)) INTO B                        05517000 D
```

```
10DC  4809 0C41 0B00 C0F0           B L = B
10DD  0000 0000 000C C020           COMP 16 = SAR
10DE  4809 EC5C 1000 C0F0           A3 OR B = A3            % A3 = (R(M))/INSTRUCTION
10DF  633C 0000 C000 0060           IFETCH - 1 = CPCR       % "Y" INTO B
10E0  4809 E000 AC00 00FC           A3 R = A2
10E1  0000 C0C0 0000 C020           16 = SAR
10E2  4809 CC40 0090 00F0           A2 + B = MIR            % Y INTO MIR
10E3  4809 E000 0B70 C0FC           A3 = B
10E4  22BC 0C00 0000 0060           CONTENTSRA - 1 = CPCR   % (R(A)) INTO B
10E5  4809 0C40 2000 C0FC           B = A2, BMI
10E6  4809 CC55 0B50 00F0           A2 AND B = MIR, B
10E7  2F5C 0000 C000 0060           EOUTPUT - 1 = CPCR
10E8  200C 00C0 C000 C06C           SETCCA - 1 = CPCR       % SET THE CONDITION BITS
10E9  66EC CCCC 0030 C040           OPCODE - 1 = MPCR
                                                            %
                                                            %
                            OP3C3:                          % RX TYPE AND
                                                            % (R(A)) AND (Y) = R(A), SET CC
10EA  570C 0000 0000 006C           RXMFIELD - 1 = CPCR     % Y INTO B
10EB  4809 0C41 0C10 C0F0           B L = BR2
10EC  0000 C0C0 0C00 C030           COMP 8 = SAR
10ED  60E0 0000 CC30 0060           EMULIN - 1 = CPCR       % (Y) INTO B
10EE  4809 CC40 0030 00F0           B = MIR
10EF  4809 EC00 0B00 00F0           A3 = B
10F0  22B0 0000 0000 0060           CONTENTSRA - 1 = CPCR   % (R(A)) INTO B
10F1  4809 0C40 2000 00F0           B = A2, BMI
10F2  4809 CC56 0B30 00F0           A2 AND B = MIR, B
10F3  2F5C C000 0C0C 0060           EOUTPUT - 1 = CPCR
10F4  2000 C000 CC3C 0060           SETCCA - 1 = CPCR       % SET THE CONDITION BITS
10F5  56E0 0000 0000 0C40           OPCODE - 1 = MPCR
                                                            %
                                                            %
10F6  5F90 0000 0000 C060   OPCODE31:  XFCODE - 1 = CFCR    % "F" INTO A2
10F7  4809 C640 0040 C0F0           A2 + AMPCR = AMPCR
10F8  193C 0C00 CC00 00C0           OP31F - 1 = AMPCR
10F9  4809 0F00 0000 00F0           STEP
10FA  4824 0003 0000 00F0           EXEC
                                                            %
10FB  1940 0000 0C0C 0040   OP31F:  OP310 - 1 = MPCR
10FC  195C 0003 0C00 0040           OP311 - 1 = MPCR
10FD  1960 C003 C00C 0040           OP312 - 1 = MPCR
10FE  1970 0003 0C30 0040           OP313 - 1 = MPCR
                                                            %
                                                            %
                            OP310:                          % RR TYPE OR (REGISTER)
                                                            % (R(A)) OR (R(M)) = R(A), SET CC
10FF  22BC 0000 0000 006C           CONTENTSRA - 1 = CFCR   % (R(A)) INTO B
1100  4809 0C40 0090 C0F0           B = MIR
1101  238C 0003 0C0C 0060           CONTENTSRM - 1 = CPCR   % (R(M)) INTO B
1102  4809 0C40 200C 00F0           B = A2, BMI
1103  4809 CC5C 0B3C 00FC           A2 OR B = MIR, B
1104  4809 E003 8C1C C0FC           A3 R = MAR2             % R(A)
1105  0000 0000 0000 0020           16 = SAR
1106  2F50 00C0 000C 0060           EOUTPUT - 1 = CPCR
1107  200C C003 C00C 0060           SETCCA - 1 = CPCR       % SET THE CONDITION BITS
1108  56E0 0000 0C00 C04C           OPCODE - 1 = MPCR
                                                            %
                                                            %
                            OP311:                          % RI TYPE 2 OR (INDIRECT)
                                                            % (R(A)) OR (Y*) = R(A), SET CC
```

```
1109  239C 0000 0000 0060             CONTENTSRM - 1 = CPCR   % Y* INTO B
110A  4809 0C41 0010 00F0             B L = BR2
110B  000C 0000 0000 0030             COMP 8 = SAR
110C  50E0 0000 0000 0060             EMULIN - 1 = CPCR       % (Y*) INTO B
110D  4809 0C40 0C80 0CF0             B = MIR
110E  4809 EC00 0B30 00F0             A3 = B
110F  2280 0000 0000 006C             CONTENTSRA - 1 = CPCR   % (R(A)) INTO B
1110  4809 CC40 2000 00FC             B = A2,BMI
1111  4809 CC5C 0B30 00F0             A2 OR B = MIR, B
1112  2F5C 0000 0000 0060             EOUTPUT - 1 = CPCR
1113  2000 0000 0000 006C             SETCCA - 1 = CPCR       % SET THE CONDITION BITS
1114  56E0 0000 0000 C040             OPCODE - 1 = MPCR
                                                              %
                                                              %
                           OP312:                             % RK TYPE OR (CONSTANT)
                                                              % (R(A)) OR Y = R(A), SET CC
1115  4809 2C55 0B30 00F0             LIT AND B = B           % ISOLATE "M"
1116  00FC 0000 0000 00E0             15 = LIT
1117  4809 0C52 0000 00F0             0 EQL B                 % CHECK FOR M = 0
1118  6819 0000 0000 00F0             IF TRUE THEN SKIP
1119  2380 0000 0000 0060             CONTENTSRM - 1 = CPCR   % (R(M)) INTO B
111A  4809 0C41 0B00 00F0             B L = B
111B  0000 0000 0000 0020             COMP 16 = SAR
111C  4809 EC5C 1000 0CFC             A3 OR B = A3            % A3 = (R(M))/INSTRUCTION
111D  6330 0000 0000 006C             IFETCH - 1 = CPCR       % "Y" INTO B
111E  4809 E000 A000 00FC             A3 R = A2
111F  00FC 0000 0000 00A0             16 = SAR; 15 = LIT
1120  4809 CC40 0030 0CF0             A2 + B = MIR            % Y INTO MIR
1121  4809 E000 0B00 00F0             A3 = B
1122  2280 0000 0000 0060             CONTENTSRA - 1 = CPCR   % (R(A)) INTO B
1123  4809 0C40 2000 0CF0             B = A2, BMI
1124  4809 CC5C 0B30 00F0             A2 OR B = MIR, B
1125  2F5C 0000 0000 0060             EOUTPUT - 1 = CPCR
1126  200C 0000 0000 006C             SETCCA - 1 = CPCR       % SET THE CONDITION BITS
1127  66E0 0000 0000 C040             OPCODE - 1 = MPCR
                                                              %
                                                              %
                           OP313:                             % RX TYPE OR
                                                              % (R(A)) OR (Y) = R(A), SET CC
1128  570C 0000 0000 0060             RXMFIELD - 1 = CPCR     % Y INTO B
1129  4809 0C41 0010 00F0             B L = BR2
112A  000C 0000 0000 0030             COMP 8 = SAR
112B  60EC 0000 0000 0060             EMULIN - 1 = CPCR       % (Y) INTO B
112C  4809 0C40 003C 00FC             B = MIR
112D  4809 E000 0B00 00F0             A3 = B
112E  2280 0000 0000 0060             CONTENTSRA - 1 = CPCR   % (R(A)) INTO B
112F  4809 CC40 2000 00F0             B = A2, BMI
1130  4809 CC5C 0B30 00FC             A2 OR B = MIR, B
1131  2F50 0000 0000 0060             EOUTPUT - 1 = CPCR
1132  2000 0000 0000 0060             SETCCA - 1 = CPCR       % SET THE CONDITION BITS
1133  66E0 0000 0000 C040             OPCODE - 1 = MPCR
                                                              %
                                                              %
1134  5F90 0000 0000 0060  OPCODE32:  XFCODE - 1 = CFCR       % "F" CODE INTO A2
1135  4809 C640 0030 00F0             A2 + AMPCR = AMPCR
1136  198C 0000 0000 0000             OP32F - 1 = AMPCR
1137  4809 C0C0 0000 00F0             STEP
1138  4824 0000 0000 00F0             EXEC
                                                              %
1139  1990 0000 0000 C040  OP32F:     OP32C - 1 = MPCR
```

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113A  19A0 0000 0000 0040            OP321 - 1 = MPCR
113B  19B0 0000 0000 C040            OP322 - 1 = MPCR
113C  19C0 0000 0000 C040            OP323 - 1 = MPCR
                                                                %                                         05641000 D
                                                                %                                         05642000 D
                          OP320:                                % RR TYPE EXCLUSIVE OR (REGISTER)         05643000 D
                                                                % (R(A)) XOR (R(M)) = R(A), SET CC        05644000 D
113D  2280 C000 0000 0060            CONTENTSRA - 1 = CPCR      % (R(A)) INTO B                           05645000 D
113E  4809 0C40 0030 00F0            B = MIR                                                              05646000 D
113F  2380 0000 0000 0060            CONTENTSRM - 1 = CPCR      % (R(M)) INTO B                           05647000 D
1140  48C9 0C40 2000 00FC            B = A2, BMI                                                          05648000 D
1141  4809 CC4C 0090 00F0            A2 XOR B = MIR, B                                                    05649000 D
1142  4809 E000 801C 00FC            A3 R = MAR2                % R(A)                                    05650000 D
1143  000C 0000 0000 0020            16 = SAR                                                             05651000 D
1144  2F5C 0000 C000 0060            EOUTPUT - 1 = CPCR                                                   05652000 D
1145  200C C000 0030 006C            SETCCA - 1 = CPCR          % SET THE CONDITION BITS                  05653000 D
1146  56E0 0000 0030 0040            OPCODE - 1 = MPCR                                                    05654000 D
                                                                %                                         05655000 D
                                                                %                                         05656000 D
                          OP321:                                % RI TYPE 2 EXCLUSIVE OR (INDIRECT)       05657000 D
                                                                % (R(A)) XOR (Y*) = R(A), SET CC          05658000 D
1147  2380 0000 0000 C060            CONTENTSRM - 1 = CPCR      % Y* INTO B                               05659000 D
1148  4809 0C41 001C C0F0            B L = BR2                                                            05660000 D
1149  0CCC CC00 0000 0030            COMP 8 = SAR                                                         05661000 D
114A  50E0 C000 0000 006C            EMULIN - 1 = CPCR          % (Y*) INTO B                             05662000 D
114B  4809 CC40 0030 00FC            B = MIR                                                              05663000 D
114C  4809 E0C0 0B00 00F0            A3 = B                                                               05664000 D
114D  228C 0000 0000 0C60            CONTENTSRA - 1 = CPCR      % (R(A)) INTO B                           05665000 D
114E  48C9 0C40 2000 00F0            B = A2,BMI                                                           05666000 D
114F  4809 CC4C 0B30 00F0            A2 XOR B = MIR, B                                                    05667000 D
1150  2F5C C000 0000 0060            EOUTPUT - 1 = CPCR                                                   05668000 D
1151  20DC 0000 0000 0060            SETCCA - 1 = CPCR          % SET THE CONDITION BITS                  05669000 D
1152  56EC 0000 000C C040            OPCODE - 1 = MPCR                                                    05670000 D
                                                                %                                         05671000 D
                                                                %                                         05672000 D
                          OP322:                                % RK TYPE EXCLUSIVE OR (CONSTANT)         05673000 D
                                                                % (R(A)) XOR Y = R(A), SET CC             05674000 D
1153  4809 2C56 0B00 00FC            LIT AND B = B              % ISOLATE "M"                             05675000 D
1154  00FC 0000 0000 C0E0            15 = LIT                                                             05676000 D
1155  4809 CC52 C000 C0F0            0 EQL B                    % CHECK FOR M = 0                         05677000 D
1156  5819 0000 0000 C0F0            IF TRUE THEN SKIP                                                    05678000 D
1157  238C C000 000C C06C            CONTENTSRM - 1 = CPCR      % (R(M)) INTO B                           05679000 D
1158  48C9 0C41 0B00 C0F0            B L = B                                                              05680000 D
1159  000C 0000 000C C020            COMP 16 = SAR                                                        05681000 D
115A  4809 EC5C 1000 00FC            A3 OR B = A3               % A3 = (R(M))/INSTRUCTION                 05682000 D
115B  5330 0000 0000 C060            IFETCH - 1 = CPCR          % "Y" INTO B                              05683000 D
115C  4809 E0C0 A000 C0F0            A3 R = A2                                                            05684000 D
115D  D0F0 0000 0000 00A0            16 = SAR; 15 = LIT                                                   05685000 D
115E  48C9 CC40 0030 C0F0            A2 + B = MIR               % Y INTO MIR                              05686000 D
115F  4809 E000 0B00 00FC            A3 = B                                                               05687000 D
1160  2280 C000 C000 0060            CONTENTSRA - 1 = CPCR      % (R(A)) INTO B                           05688000 D
1161  4809 0C40 2000 00FC            B = A2, BMI                                                          05689000 D
1162  4809 CC4C 0B9C C0F0            A2 XOR B = MIR, B                                                    05690000 D
1163  2F50 0000 000C 0060            EOUTPUT - 1 = CPCR                                                   05691000 D
1164  20DC 0000 C000 C060            SETCCA - 1 = CPCR          % SET THE CONDITION BITS                  05692000 D
1165  66E0 0000 CC0C C040            OPCODE - 1 = MPCR                                                    05693000 D
                                                                %                                         05694000 D
                                                                %                                         05695000 D
                          OP323:                                % RX TYPE EXCLUSIVE OR                    05696000 D
                                                                % (R(A)) XOR (Y) = R(A), SET CC           05697000 D
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1166  5700 C000 C00C C060          RXMFIELD - 1 = CFCR     % Y INTO B                                      05698C00 D
1167  4809 0041 0010 00F0          B L = BR2                                                               05699C00 D
1168  0000 C000 000C C030          COMP B = SAR                                                            05700000 D
1169  60EC 0000 000C 006C          EMULIN - 1 = CPCR       % (Y) INTO B                                    05701C00 D
116A  4809 0040 0030 00F0          B = MIR                                                                 05702C00 D
116B  4809 E000 CB0C C0F0          A3 = B                                                                  05703C00 D
116C  22BC 0000 000C 0060          CONTENTSRA - 1 = CPCR   % (R(A)) INTO B                                 05704C00 D
116D  4809 0040 2D0C 00F0          B = A2, BMI                                                             05705C0C D
116E  4809 CC4C 0B3C 00F0          A2 XOR B = MIR, B                                                       05706C00 C
116F  2F50 CCC0 0C0C C060          EDUTPUT - 1 = CPCR                                                      05707C0C D
1170  20DC CCC0 000C C060          SETCCA - 1 = CPCR       % SET THE CONDITION BITS                        05708C00 D
1171  66EC C000 0C00 C04C          OPCODE - 1 = MPCR                                                       05709CCC D
                                                           %                                               05710C0C D
                                                           %                                               05711C00 D
1172  5F90 CCC0 0000 C060  OPCODE33:  XFCODE - 1 = CPCR    % "F" INTO A2                                   05712C00 D
1173  4809 C640 0C40 00F0          A2 + AMPCR = AMPCR                                                      05713C0C D
1174  19DC 0000 0000 00C0          OP33F - 1 = AMPCR                                                       05714C00 D
1175  4809 0000 000C C0FC          STEP                                                                    05715C00 D
1176  4824 C000 0C0C 00FC          EXEC                                                                    05716C00 D
                                                           %                                               05717C00 D
1177  19EC C000 000C 0040  OP33F:  OP330 - 1 = MPCR                                                        05718C0C D
1178  19FC 0000 0000 C040          OP331 - 1 = MPCR                                                        05719000 C
1179  1A0C 0000 CC0C 0040          OP332 - 1 = MPCR                                                        05720C0C D
117A  1A10 0000 0C00 C040          OP333 - 1 = MPCR                                                        05721CC0 D
                           OP330:                          % TYPE RR MASKED SUBSTITUTE (REGISTER)          05722C00 D
                                                           % IF (R(A+1))N = 1, (R(M)) INTO R(A)N, CC05723C00 D
117B  2380 0000 000C 0060          CONTENTSRM - 1 = CPCR   % (R(M)) INTO B                                 05724CCC D
117C  4809 0C40 0C9C C0FC          B = MIR                 % TEMP STORAGE                                  05725C00 D
117D  4809 E0C0 8B00 00FC          A3 R = B                                                                05726C00 D
117E  30FC C0C0 C00C 0080          4 = SAR; 15 = LIT                                                       05727C0C D
117F  4809 2C56 0B0C C0F0          LIT AND B = B           % ISOLATE "A"                                   05728C00 D
1180  51C0 0000 0C0C 0060          REGSTACK - 1 = CPCR     % R(A) INTO MAR2                                05729000 D
1181  48C9 0F41 0C2C 00F0          BMAR L = BR1            % STORE R(A)                                    05730C00 D
1182  00C0 0000 0C00 003C          COMP B = SAR                                                            05731C00 D
1183  48C9 0F46 0B0C 00F0          BMAR + 1 = B            % R(A+1)                                        05732C00 D
1184  51CC 0000 0C00 006C          REGSTACK - 1 = CPCR     % R(A+1) INTO MAR2                              05733C00 D
1185  2F3C C000 0000 C060          EINPUT - 1 = CPCR       % (R(A+1)) INTO B                               05734C00 D
1186  4809 0040 2D0C 00F0          B = A2, BHI                                                             05735C00 D
1187  4809 CC56 003C C0F0          A2 AND B = MIR          % (R(A+1)) AND (R(M))                           05736C0C D
1188  4809 0000 0000 20FC          ASR                     % REFERENCE BR1                                 05737C00 D
1189  4809 0F43 801C 00FC          BMAR R = MAR2                                                           05738C00 D
118A  00C0 C000 000C C010          8 = SAR                                                                 05739C0C D
118B  2F3C 0000 C0D0 C06C          EINPUT - 1 = CPCR       % (R(A)) INTO B                                 05740CCC D
118C  48C9 0C40 2D0C CCF0          B = A2,BMI                                                              05741C00 D
118D  4809 CC5C 0B3C 00F0          A2 OR B = MIR, B                                                        05742C00 D
118E  2F5C 0000 C000 0060          FOUTPUT - 1 = CPCR                                                      05743000 D
118F  20DC CCC0 0000 0060          SETCCA - 1 = CPCR       % SET THE CONDITION BITS                        05744000 D
1190  66EC 0CC0 000C C040          CPCODE - 1 = MPCR                                                       05745C00 D
                                                           %                                               05746CC0 D
                                                           %                                               05747C00 D
                           OP331:                          % RI TYPE 2 MASKED SUBSTITUTE (INDIRECT)        05748C00 D
                                                           % IF (R(A+1))N=1, (Y*)N = R(A)N, SET CC         05749C0C D
1191  238C 0000 C000 C060          CONTENTSRM - 1 = CFCR   % (R(M)) INTO B                                 05750C00 D
1192  4809 0041 001C 00F0          B L = BR2                                                               05751CC0 D
1193  000C 0CC0 000C 0030          COMP 8 = SAR                                                            05752000 D
1194  60EC 0CC0 000C 0060          EMULIN - 1 = CPCF       % (Y*) INTO B                                   05753C00 D
1195  4809 CC40 0C3C C0F0          B = MIR                 % TEMP STORAGE                                  05754C0C D
1196  4809 E0C0 8B0C C0FC          A3 R = B                                                                05755C00 D
1197  30FC 00C0 0C0C C080          4 = SAR; 15 = LIT                                                       05756C0C D
1198  48C9 2C56 0B0C C0FC          LIT AND B = B           % ISOLATE "A"                                   05757C00 D
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1199  51CC 0000 0000 0060        REGSTACK - 1 = CPCR     % R(A) INTO MAR2                          05758000 D
119A  4809 0F41 0070 00FC        BMAR L = BR1            % TEMP STORAGE                            05759000 D
119B  000C 0000 0030 0030        COMP 8 = SAR                                                      05760000 D
119C  4809 0F45 0B30 00F0        BMAR + 1 = B            % R(A+1)                                  05761000 D
119D  51CC 0000 0000 0060        REGSTACK - 1 = CPCR     % R(A+1) INTO MAR2                        05762000 D
119E  2F30 0000 0000 006C        EINPUT - 1 = CPCR       % (R(A+1)) INTO B                         05763000 D
119F  4809 0C40 2000 00F0        D = A2, BMI                                                       05764000 D
11A0  4809 CC56 0030 00F0        A2 AND B = MIR          % (R(A+1)) AND (Y*)                       05765000 D
11A1  4809 0C00 0C00 20F0        ASR                     % REFERENCE DR1                           05766000 D
11A2  4809 0F43 801C 00F0        BMAR R = MAR2           % R(A)                                    05767000 D
11A3  000C 0000 0000 001C        8 = SAR                                                           05768000 D
11A4  2F30 0000 0000 0060        EINPUT - 1 = CPCR       % (R(A)) INTO B                           05769000 D
11A5  4809 0C40 2030 00F0        B = A2,BMI                                                        05770000 D
11A6  4809 CC5C 0B90 00FC        A2 OR B = MIR, B                                                  05771000 D
11A7  2F50 0000 0030 006C        EOUTPUT - 1 = CFCR                                                05772000 D
11A8  200C 0000 0000 0060        SETCCA - 1 = CPCR       % SET THE CONDITION BITS                  05773000 D
11A9  66E0 0000 0000 0040        OPCODE - 1 = MPCR                                                 05774000 D
                                                         %                                         05775000 D
                                                         %                                         05776000 D
                           OP332:                        % RK TYPE MASKED SUBSTITUTE (CONSTANT)    05777000 D
                                                         % IF (R(A+1))N= 1, YN INTO R(A)N, SET CC  05778000 D
11AA  4809 2C56 0B30 00F0        LIT AND 8 = B           % ISOLATE "M"                             05779000 D
11AB  00FC 0000 0030 00E0        15 = LIT                                                          05780000 D
11AC  4809 0C52 0030 00F0        0 EOL B                 % CHECK FOR M = 0                         05781000 D
11AD  6819 0000 0000 00FC        IF TRUE THEN SKIP                                                 05782000 D
11AE  2380 0000 000C 0060        CONTENTSRM - 1 = CPCR   % (R(M)) INTO B                           05783000 D
11AF  4809 0C41 0830 00FC        B L = B                                                           05784000 D
11B0  000C 0000 0000 002C        COMP 16 = SAR                                                     05785000 D
11B1  4809 EC5C 1000 00F0        A3 OR B = A3            % A3 = (R(M))/INSTRUCTION                 05786000 D
11B2  633C 0000 0000 0060        IFETCH - 1 = CPCR       % "Y" INTO B                              05787000 D
11B3  4809 EC03 A000 00F0        A3 R = A2               % (R(M)) INTO A2                          05788000 D
11B4  000C 0003 0000 0020        16 = SAR                                                          05789000 D
11B5  4809 CC40 0C80 00F0        A2 + B = MIR            % Y INTO MIR                              05790000 D
11B6  4809 E003 8B0C 00F0        A3 R = B                                                          05791000 D
11B7  80FC 0003 0070 0080        4 = SAR; 15 = LIT                                                 05792000 D
11B8  4809 2C56 0B00 0CF0        LIT AND B = B           % ISOLATE "A"                             05793000 D
11B9  51CC 0000 0030 0060        REGSTACK - 1 = CPCR     % R(A) INTO MAR2                          05794000 D
11BA  4809 0F41 0C2C 00FC        BMAR L = BR1            % TEMP STORAGE                            05795000 D
11BB  000C 0000 0030 0030        COMP 8 = SAR                                                      05796000 D
11BC  4809 0F46 0B3C 00F0        BMAR + 1 = B            % R(A+1)                                  05797000 D
11BD  51C0 0000 000C 006C        REGSTACK - 1 = CPCR     % R(A+1) INTO MAR2                        05798000 D
11BE  2F30 0000 0000 0060        EINPUT - 1 = CPCR       % (R(A+1)) INTO B                         05799000 D
11BF  4809 CC43 2030 00F0        B = A2, BMI                                                       05800000 D
11C0  4809 CC56 003C 00F0        A2 AND B = MIR          % (R(A+1)) AND Y                          05801000 D
11C1  4809 C000 0000 20FC        ASR                     % REFERENCE BR1                           05802000 D
11C2  4809 0F43 801C 00F0        BMAR R = MAR2           % R(A)                                    05803000 D
11C3  0000 0003 0C0C C010        8 = SAR                                                           05804000 D
11C4  2F30 0000 0030 C060        EINPUT - 1 = CPCR       % (R(A)) INTO B                           05805000 D
11C5  4809 0C40 2090 C0FC        B = A2,BMI                                                        05806000 D
11C6  4809 CC5C 0B90 00F0        A2 OR B = MIR, B                                                  05807000 D
11C7  2F5C 0000 0000 C060        EOUTPUT - 1 = CPCR                                                05808000 D
11C8  200C 0000 000C C060        SETCCA - 1 = CPCR       % SET THE CONDITION BITS                  05809000 D
11C9  66E0 0000 0070 0040        OPCODE - 1 = MPCR                                                 05810000 D
                                                         %                                         05811000 D
                                                         %                                         05812000 D
                           OP333:                        % RX TYPE MASKED SUBSTITUTE               05813000 D
                                                         % IF (R(A+1))N= 1, (Y)N INTO R(A), SET CC05814000 D
11CA  570C 0000 0000 0060        RXMFIELD - 1 = CFCR     % Y INTO B                                05815000 D
11CB  4809 CC41 C010 00F0        B L = BR2                                                         05816000 D
11CC  0000 0C00 0000 0030        COMP 8 = SAR                                                      05817000 D
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11CD  60EC 0000 0000 0060              FMULIN - 1 = CPCR       % (Y) INTO B                            05818000 D
11CE  4809 0C40 0090 C0F0              D = MIR                 % TEMP STORAGE                          05819000 D
11CF  4809 E000 8B00 00F0              A3 R = B                                                        05820000 D
11D0  80FC C000 0000 0080              4 = SAR; 15 = LIT                                               05821000 D
11D1  4809 2C56 0B00 C0F0              LIT AND B = B           % ISOLATE "A"                           05822000 D
11D2  51C0 0000 0000 C060              REGSTACK - 1 = CPCR     % R(A) INTO MAR2                        05823000 D
11D3  4809 0F4L 0020 00F0              BMAR L = BR1            % TEMP STORAGE                          05824000 D
11D4  0000 C0C0 0C0C 0030              COMP B = SAR                                                    05825000 D
11D5  4809 0F45 0B00 00FC              BMAR + 1 = B            % R(A+1)                                05826000 D
11D6  51C0 C0C0 0000 0060              REGSTACK - 1 = CFCR     % R(A+1) INTO MAR2                      05827000 D
11D7  2F30 0000 0000 0060              EINPUT - 1 = CPCR       % (R(A+1)) INTO B                       05828000 D
11D8  4809 0C40 2D0C C0F0              D = A2, BMI                                                     05829000 D
11D9  4809 CC56 000C C0F0              A2 AND B = MIR          % (R(A+1)) AND (Y)                      05830000 D
11DA  4809 C000 0000 20F0              ASR                     % REFERENCE BR1                         05831000 D
11DB  4809 CF43 8C1C 00FC              BMAR R = MAR2                                                   05832000 D
11DC  000C 00C0 0000 0010              B = SAR                                                         05833000 D
11DD  2F30 0000 0000 C060              EINPUT - 1 = CPCR       % (R(A)) INTO D                         05834000 D
11DE  4809 0C40 2000 C0F0              B = A2,BMI                                                      05835000 D
11DF  4809 CC5C 0B90 00F0              A2 OR B = MIR, B                                                05836000 D
11E0  2F50 00C0 0000 0060              EOUTPUT --1 = CPCR                                              05837000 D
11E1  2000 0000 0000 0060              SETCCA - 1 = CPCR       % SET THE CONDITION BITS                05838000 D
11E2  66E0 0000 0000 0040              OPCODE - 1 = MPCR                                               05839000 D
                                                               %                                       05840000 D
                                                               %                                       05841000 D
11E3  5F90 0000 0000 0060   OPCODE34:  XFCODE - 1 = CFCR       % "F" INTO A2                           05842000 D
11E4  4809 C640 0040 C0F0              A2 + AMPCR = AMPCR                                              05843000 D
11E5  1A20 0000 0000 00C0              OP34F - 1 = AMPCR                                               05844000 D
11E6  4809 0000 0000 00F0              STEP                                                            05845000 D
11E7  4824 0000 0000 C0F0              EXEC                                                            05846000 D
                                                               %                                       05847000 D
11E8  1A30 0000 0000 0040   OP34F:     OP340 - 1 = MPCR                                                05848000 D
11E9  1A40 0000 0000 004C              OP341 - 1 = MPCR                                                05849000 D
11EA  1A5C 0000 0000 C040              OP342 - 1 = MPCR                                                05850000 D
11ED  1A60 0000 0000 C040              OP343 - 1 = MPCR                                                05851000 D
                                                               %                                       05852000 D
                                                               %                                       05853000 D
                            OP340:                             % TYPE RR COMPARE MASKED (REGISTER)     05854000 D
                                                               % (R(A)) AND (R(A+1)) : (R(M)) AND      05855000 D
                                                               % (R(A+1)), SET CC                      05856000 D
11EC  238C 0000 0000 C060              CONTENTSRM - 1 = CPCR   % (R(M)) INTO B                         05857000 D
11ED  4809 0C40 0090 00F0              D = MIR                 % TEMP STORAGE                          05858000 D
11EE  4809 E000 8B00 C0F0              A3 R = B                                                        05859000 D
11EF  80FC 0000 0000 C080              4 = SAR; 15 = LIT                                               05860000 D
11F0  4809 2C56 0B00 00FC              LIT AND B = B           % ISOLATE "A"                           05861000 D
11F1  51CC C000 0000 C06C              REGSTACK - 1 = CFCR                                             05862000 D
11F2  2F30 0000 0000 C060              EINPUT - 1 = CPCR       % (R(A)) INTO B                         05863000 D
11F3  4809 0C40 2000 00F0              B = A2                                                          05864000 D
11F4  4809 CF46 CB00 CCF0              BMAR + 1 = B            % R(A+1)                                05865000 D
11F5  51CC 0000 0000 0060              REGSTACK - 1 = CPCR     % R(A+1) INTO MAR2                      05866000 D
11F6  2F30 C000 000C 0060              EINPUT - 1 = CPCR       % (R(A+1)) INTO B                       05867000 D
11F7  4809 CC56 2000 00F0              A2 AND B = A2           % (R(A)) AND (R(A+1))                   05868000 D
11F8  4809 0C40 1000 C0F0              B = A3, BMI                                                     05869000 D
11F9  4809 EC56 0B00 00F0              A3 AND B = B            % (R(M)) AND (R(A+1))                   05870000 D
11FA  2000 0000 0000 0060              SETCC - 1 = CPCR        % SET THE CONDITION BITS                05871000 D
11FB  66E0 0000 0000 C040              OPCODE - 1 = MPCR                                               05872000 D
                                                               %                                       05873000 D
                                                               %                                       05874000 D
                            OP341:                             % RI TYPE 2 COMPARE MASKED(INDIRECT)    05875000 D
                                                               % (R(A)) AND (R(A+1)) : (Y*) AND (R(A+1))05876000 D
                                                               % AND SET CC                            05877000 D
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11FC  238C 0000 0000 0060          CONTENTSRM - 1 = CPCR  % Y* INTO B                                   05878000 D
11FD  4809 0C41 0010 C0FD          B L = BR2                                                            05879000 D
11FE  0C00 CCC0 0030 C030          COMP 8 = SAR                                                         05880000 D
11FF  60EC 0000 0000 0060          EMULIN - 1 = CPCR      % (Y*) INTO B                                 05881000 D
1200  4809 0C40 0030 C0FC          B = MIR                % TEMP STORAGE                                05882000 D
1201  4809 E000 8800 00F0          A3 R = B                                                             05883000 D
1202  80FC 0003 C00C C080          4 = SAR; 15 = LIT                                                    05884000 D
1203  4809 2C56 0B30 0CFC          LIT AND B = B          % ISOLATE "A"                                 05885000 D
1204  51C0 0000 C000 006D          REGSTACK - 1 = CPCR                                                  05886000 D
1205  2F30 0000 0030 C06D          EINPUT - 1 = CPCR      % (R(A)) INTO B                               05887000 D
1206  4809 0C40 2C00 CDF0          B = A2                                                               05888000 D
1207  4809 0F45 0B30 00F0          BMAR + 1 = B           % R(A+1)                                      05889000 D
1208  51CC C000 C090 006D          REGSTACK - 1 = CPCR    % R(A+1) INTO MAR2                            05890000 D
1209  2F3C 0000 0C00 0060          EINPUT - 1 = CPCR      % (R(A+1)) INTO B                             05891000 D
120A  4609 CC56 2030 C0FC          A2 AND B = A2          % (R(A)) AND (R(A+1))                         05892000 D
120B  4809 0C40 1030 C0FC          B = A3, BMI                                                          05893000 D
120C  4809 EC56 0D30 CCFD          A3 AND B = D           % (Y*) AND (R(A+1))                           05894000 D
120D  200C 0CC0 CCCC 0060          SETCC - 1 = CPCR       % SET THE CONDITION BITS                      05895000 D
120E  66E0 C000 0C00 C040          OPCODE - 1 = MPCR                                                    05896000 D
                                                          %                                             05897000 D
                                                          %                                             05898000 D
                             OP342:                       % TYPE RK COMPARE MASKED (CONSTANT)           05899000 D
                                                          % (R(A)) AND (R(A+1)) : Y AND (R(A+1)),       05900000 D
                                                          % AND SET CONDITION BITS                      05901000 D
120F  4809 2C56 0E00 C0FD          LIT AND B = B          % ISOLATE M                                   05902000 D
1210  00F0 0000 0C00 00EC          15 = LIT                                                             05903000 D
1211  4809 0C52 0000 00F0          0 EQL B                % CHECK FOR M = 0                             05904000 D
1212  6819 0000 0030 00FD          IF TRUE THEN SKIF                                                    05905000 D
1213  238C 0000 0030 C06C          CONTENTSRM - 1 = CPCR  % (R(M)) INTO B                               05906000 D
1214  4809 0C41 0B30 00FD          B L = B                                                              05907000 D
1215  C000 C0C0 0030 0D20          COMP 16 = SAR                                                        05908000 D
1216  4809 EC5C 1030 0DFD          A3 OR B = A3           % A3 = (R(M))/INSTRUCTION                     05909000 D
1217  5330 0000 000C 0060          IFETCH - 1 = CPCR      % "Y" INTO B                                  05910000 D
1218  4809 E000 A030 C0F0          A3 R = A2              % (R(M)) INTO A2                              05911000 D
1219  000C 00C0 000C D020          16 = SAR                                                             05912000 D
121A  4809 CC40 C090 00F0          A2 + B = MIR           % Y INTO D                                    05913000 D
121B  4809 E0C0 8B0C C0F0          A3 R = B                                                             05914000 D
121C  80FC 0000 0030 C080          4 = SAR; 15 = LIT                                                    05915000 D
121D  4809 2C55 0B30 0CF0          LIT AND B = B          % ISOLATE "A"                                 05916000 D
121E  51C0 C0C0 000C C06C          REGSTACK - 1 = CPCR    % R(A) INTO MAR2                              05917000 D
121F  2F30 00C0 C0CC 006C          EINPUT - 1 = CPCR      % (R(A)) INTO B                               05918000 D
1220  4809 0C40 2030 C0F0          B = A2                                                               05919000 D
1221  4609 CF45 0B00 C0FC          BMAR + 1 = B           % R(A+1)                                      05920000 D
1222  51CC 0CC0 000C C060          REGSTACK - 1 = CPCR    % R(A+1) INTO MAR2                            05921000 D
1223  2F3C 0CC0 0030 006C          EINPUT - 1 = CPCR      % (R(A+1)) INTO B                             05922000 D
1224  4809 CC56 2030 00F0          A2 AND B = A2          % (R(A)) AND (R(A+1))                         05923000 D
1225  4809 CC40 1030 00F0          B = A3, BMI                                                          05924000 D
1226  4809 EC56 0B30 C0F0          A3 AND B = B           % Y AND (R(A+1))                              05925000 D
1227  2000 C000 000C CD60          SETCC - 1 = CPCR       % SET THE CONDITION BITS                      05926000 D
1228  66E0 0000 0030 C040          OPCODE - 1 = MPCR                                                    05927000 D
                                                          %                                             05928000 D
                                                          %                                             05929000 D
                             OP343:                       % RX TYPE COMPARE MASKED                      05930000 D
                                                          % (R(A)) AND (R(A+1)) : (Y) AND (R(A+1))      05931000 D
                                                          % AND SET CONDITION BITS                      05932000 D
1229  570C 0000 0030 C06C          RXMFIELD - 1 = CPCR    % Y INTO B                                    05933000 D
122A  4809 0C41 0010 00FC          B L = BR2                                                            05934000 D
122B  0000 0000 0C00 C030          COMP 8 = SAR                                                         05935000 D
122C  60E0 0000 0000 006C          EMULIN - 1 = CPCR      % (Y) INTO B                                  05936000 D
122D  4809 0C40 D030 00FC          B = MIR                % TEMP STORAGE                                05937000 D
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122E  4809 E000 8B00 00FC            A3 R = B                                          05938000 D
122F  80F0 0000 0000 0080            4 = SAR; 15 = LIT                                 05939000 D
1230  4809 2C56 0B00 00FC            LIT AND B = B          % ISOLATE "A"              05940000 D
1231  51C0 0000 0000 0060            REGSTACK - 1 = CPCR    % R(A) INTO MAR2           05941000 D
1232  2F30 0000 0000 0060            EINPUT - 1 = CPCR      % (R(A)) INTO E            05942000 D
1233  4809 0C40 2000 C0F0            B = A2                                            05943000 D
1234  4809 0F46 0B00 C0FC            BMAR + 1 = B           % R(A+1)                   05944000 D
1235  51C0 0000 0000 0060            REGSTACK - 1 = CPCR    % R(A+1) INTO MAR2         05945000 D
1236  2F30 0000 0000 0060            EINPUT - 1 = CPCR      % (R(A+1)) INTO B          05946000 D
1237  4809 CC56 2000 00FC            A2 AND B = A2          % (R(A)) AND (R(A+1))      05947000 D
1238  4809 CC40 1000 00F0            B = A3, BMI                                       05948000 D
1239  4809 EC56 0B00 00F0            A3 AND B = B           % (Y) AND (R(A+1))         05949000 D
123A  2000 0000 0000 C060            SETCC - 1 = CPCR       % SET THE CONDITION BITS   05950000 D
123B  66E0 0000 0000 C040            OPCODE - 1 = MPCR                                 05951000 D
                                                            %                          05952000 D
123C  5F90 0000 0000 0060  OPCODE35:  XFCODE - 1 = CPCR     % "F" INTO A2              05953000 D
123D  4809 C640 0040 00FC            A2 + AMPCR = AMPCR                                05954000 D
123E  1A70 0000 0000 C0C0            OP35F- 1 = AMPCR                                  05955000 D
123F  4809 0000 0000 00FC            STEP                                              05956000 D
1240  4824 0000 0000 C0FC            EXEC                                              05957000 D
                                                            %                          05958000 D
1241  1A8C 0000 0000 0040  OP35F:    OP350 - 1 = MPCR                                  05959000 D
1242  1A90 0000 0000 0040            OP351 - 1 = MPCR                                  05960000 D
1243  1AAC C000 0000 C04C            OP352 - 1 = MPCR                                  05961000 D
1244  1AB0 0000 0000 0040            OP353 - 1 = MPCR                                  05962000 D
                                                            %                          05963000 D
                           OP350:                           % INPUT OUTPUT COMMAND WORD FETCH (5C)  05964000 D
                                                            % IOCW IS LOADED PRIOR TO EXECUTING THIS 05965000 D
                                                            % INSTRUCTION              05966000 D
1245  4809 2C56 0B00 00FC            LIT AND B = B          % :M: AND :A: FIELDS MUST BE ZERO ELSE  05967000 D
                                                            % FAULT ENTERED.           05968000 D
1246  80FC 0000 0000 0080            15 = LIT; 4 = SAR                                 05969000 D
1247  4809 CC52 000C C0F0            C NEQ B                                           05970000 D
1248  600B 0000 C000 00F0            IF TRUE THEN STEP ELSE SKIP                       05971000 D
1249  3000 0000 0000 004C            FAULT - 1 = MPCR                                  05972000 D
124A  4809 E000 8B00 C0FC            A3 R = B                                          05973000 D
124B  4809 2C55 0B00 C0F0            LIT AND B = B                                     05974000 D
124C  4809 CC52 0C00 00F0            0 NEQ B                                           05975000 D
124D  600B 0000 CC0C C0FC            IF TRUE THEN STEP ELSE SKIP                       05976000 D
124E  3C0C 0000 0000 C040            FAULT - 1 = MPCR                                  05977000 D
124F  4809 2000 0C1C 00F0            LIT = MAR2                                        05978000 D
1250  A32C 0000 0000 C080            IOCW = LIT; 6 = SAR                               05979000 D
1251  2F30 0000 000C C060            EINPUT - 1 = CPCR      % B = (IOCW)               05980000 D
1252  4809 CC40 2000 C0F0            B = A2                 % STORE (IOCW) IN A2       05981000 D
1253  4809 0C41 0B10 00FC            B L = B                % ISOLATE NO OF BUFFERS IN UHW OF B     05982000 D
1254  A000 0000 0000 001C            COMP 18 = SAR                                     05983000 D
1255  4809 0C40 8B00 00FC            B R = B                                           05984000 D
1256  000C C0C0 000C C010            B = SAR                % SHIFT NO. OF BUFFERS IN UHW OF B      05985000 D
1257  4809 EC5C 1000 00F0            A3 OR B = A3           % STORE BUFFER COUNT IN UHW OF A3       05986000 D
1258  4809 C000 000C C0F0            A2                     % TEST BIT FOR I/O         05987000 D
1259  580B 0000 000C C0F0            IF LST THEN STEP ELSE SKIP                        05988000 D
125A  367C 0000 0000 0040            EOUT - 1 = MPCR                                   05989000 D
125B  3B4C C000 0000 C040            IN - 1 = MPCR                                     05990000 D
                                                            %                          05991000 D
                                                            %                          05992000 D
                           OP351:                           % RI TYPE 2 BIASED FETCH   05993000 D
                                                            % (Y*) BIT 15 INTO CC: 1 = Y* BITS 15,14 05994000 D
                                                            % SET CC                   05995000 D
125C  238C 0000 0000 0060            CONTENTSRM - 1 = CPCR  % Y* INTO B                05996000 D
125D  4809 0C41 0010 C0FC            B L = BR2              % Y* INTO BR2              05997000 D
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125E  0000 0C00 0000 0030            COMP 8 = SAR                                         05998000 D
125F  50EC 00C0 0000 0060            EMULIN - 1 = CPCR       % (Y*) INTO B                05999000 D
1260  48C9 0C41 1800 00F0            B L = B, A3             % (Y*) INTO MS WORD OF B, A3 06000000 D
1261  000C 0C00 000C 0020            COMP 16 = SAR                                        06001000 D
1262  4009 CC40 000C 00F0            B                       % B TO THE ADDER             06002000 D
1263  400E 0003 000C 00F0            IF NOT MST THEN STEP ELSE SKIP                       06003000 D
1264  1AC0 0000 0000 0040            P351 - 1 = MPCR         % POSITIVE CASE              06004000 D
1265  216C 00C0 000C 0060            SET11 - 1 = CPCR        % SET THE CONDITION BITS     06005000 D
1266  4809 00C1 0B00 00F0            1 L = B                                              06006000 D
1267  200C 0000 0000 0000            COMP 30 = SAR                                        06007000 D
1268  4809 EC5C 8B30 00FC            A3 OR B R = MIR, D      % SET BIT 14 OF (Y*)         06008000 D
1269  0000 00C0 000C C020            16 = SAR                                             06009000 D
126A  4809 0F41 0010 00FC            BMAR L = BR2            % RESTORE Y* INTO BR2        06010000 D
126B  000C C000 0030 CC30            COMP 8 = SAR                                         06011000 D
126C  51E0 0000 0030 C060            EMULOUT - 1 = CPCR                                   06012000 D
126D  665C 00C0 000C 0040            OPCODE - 1 = MPCR                                    06013000 D
126E  4809 A001 C00C 40F0   P351:    A1 C = A1,CSAR          % PUT CC BIT 9 INTO LS BIT   06014000 D
126F  1C0C 00C0 0030 0030            25 = SAR                                             06015000 D
1270  4809 A0CF C000 00F0            A1 AND B110 C = A1      % SET BIT 9 TO 0, AND RESTORE A1  06016000 D
1271  48C9 CC41 8B0C C0F0            B C = B                                              06017000 D
1272  A00C 00C0 000C 0030            30 = SAR                                             06018000 D
1273  4809 2C5D 8C3C C0F0            LIT OR B C = MIR        % SET (Y*) BITS 14,15        06019000 D
1274  2030 0000 000C C0A0            3 = LIT; 18 = SAR                                    06020000 D
1275  4809 0F41 0C10 0CF0            BMAR L = BR2            % RESTORE Y* INTO BR2        06021000 D
1276  D00C 00C0 C000 0030            COMP 8 = SAR                                         06022000 D
1277  61E0 00C0 0C0C C060            EMULOUT - 1 = CPCR                                   06023000 D
1278  66EC 00C0 0C30 C040            OPCODE - 1 = MPCR                                    06024000 D
                                                             %                            06025000 D
                                                             %                            06026000 D
                            OP352:                           % TYPE RK REMOTE EXECUTE     06027000 D
                                                             % EXECUTE (Y); (P) + 2 = P   06028000 D
1279  4809 2C56 CB3C 00F0            LIT AND B = B           % ISOLATE "M"                06029000 D
127A  00F0 00C0 C00C 00E0            15 = LIT                                             06030000 D
127B  4809 CC52 0C00 00F0            0 EQL B                                              06031000 D
127C  6819 00C0 0000 C0F0            IF TRUE THEN SKIP                                    06032000 D
127D  238C C0C0 0000 0C60            CONTENTSRM - 1 = CPCR   % (R(M)) INTO B              06033000 D
127E  4809 0C41 0B30 C0F0            B L = B                                              06034000 D
127F  0C0C 0000 000C 0020            COMP 16 = SAR                                        06035000 D
1280  4809 EC5C 100C C0F0            A3 OR B = A3            % A3 = (R(M)) OR 0 /INSTRUCTION  06036000 D
1281  633C 00C3 0C30 0060            IFETCH - 1 = CPCR       % "Y" INTO B                 06037000 D
1282  4809 E0C0 AC00 C0F0            A3 R = A2               % (R(M)) OR 0 INTO A2        06038000 D
1283  0200 00C0 0030 C0A0            PSW = LIT; 16 = SAR                                  06039000 D
1284  4809 CC40 0C30 00F0            A2 + B = MIR            % Y INTO MIR                 06040000 D
1285  4809 2203 0C1C 00F0            LIT = MAR2                                           06041000 D
1286  2F5C C003 000C C06C            EOUTPUT - 1 = CPCR      % Y INTO PSW                 06042000 D
1287  4809 B81C 400C 00F0            A1 OR B1C0 = A1         % SET BIT 31 OF SR#1, REMOTE EXEC BIT  06043000 D
1288  66E0 0000 C000 0040            OPCODE - 1 = MPCR                                    06044000 D
                                                             %                            06045000 D
                                                             %                            06046000 D
                            OP353:                           % TYPE RX BIASED FETCH, (Y) BIT 15 IN CC  06047000 D
                                                             % 1 = (Y) BIT 15             06048000 D
1289  570C 00C0 0C0C C060            RXMFIELD - 1 = CPCR     % Y INTO B                   06049000 D
128A  4809 0C41 1C1C C0F0            B L = BR2, A3                                        06050000 D
128B  000C 0CC0 0C0C C03C            COMP 8 = SAR                                         06051000 D
128C  60E0 C0C3 0C30 C06C            EMULIN - 1 = CPCR       % (Y) INTO B                 06052000 D
128D  4809 0C41 0B3C 00F0            B L = B                                              06053000 D
128E  C00C 00C0 C03C C020            COMP 16 = SAR                                        06054000 D
128F  4809 CC40 000C 00F0            B                                                    06055000 D
1290  400B 00C0 0000 00F0            IF NOT MST THEN STEP ELSE SKIP                       06056000 D
1291  1ADC 00C0 0C0C C040            P353 - 1 = MPCR                                      06057000 D
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1292  2160 0000 0000 C060               SET11 - 1 = CPCR       * SET THE CONDITION BITS                  06058000 D
1293  4809 00C1 2000 C0F0               1 L = A2                                                         06059000 D
1294  2000 0000 0000 0000               COMP 30 = SAR                                                    06060000 D
1295  4809 CC5C 8B30 C0F0               A2 OR B R = MIR, B     * SET BIT 14 OF (Y)                       06061000 D
1296  0000 0000 0000 0020               16 = SAR                                                         06062000 D
1297  4809 E000 0010 C0F0               A3 = BR2               * RESTORE Y INTO BR2                      06063000 D
1298  61E0 0000 0000 C060               EMULOUT - 1 = CPCR                                               06064000 D
1299  66E0 0000 C000 0040               OPCODE - 1 = MPCR                                                06065000 D
129A  4809 A0C1 CC0C 40F0     P353:     A1 C = A1,CSAR         * PUT CC BIT 9 INTO LS BIT                06066000 D
129B  1000 0000 0000 0030               25 = SAR                                                         06067000 D
129C  4809 A0CF C000 00F0               A1 AND B110 C = A1     * SET BIT 9 TO 0, AND RESTORE A1          06068000 D
129D  4809 0C41 8B30 00F0               B C = B                                                          06069000 D
129E  AC0C 0000 0030 C030               30 = SAR                                                         06070000 D
129F  4809 2C5D 8C9C 00F0               LIT OR D C = MIR       * SET (Y) BIT 14,15                       06071000 D
12A0  2030 C000 0000 C0A0               3 = LIT; 18 = SAR                                                06072000 D
12A1  4809 E000 C01C 00F0               A3 = BR2               * RESTORE Y INTO BR2                      06073000 C
12A2  61E0 0000 000C C060               EMULOUT - 1 = CPCR                                               06074000 D
12A3  66E0 0000 0000 CC40               OPCODE - 1 = MPCR                                                06075000 D
                                                               *                                         06076000 D
                                                               *                                         06077000 D
                              OPCODE36:                        * NOT ASSIGNED. GENERATES INTERRUPT       06078000 D
                                                               * FAULT.                                  06079000 D
12A4  3000 0000 0030 0040               FAULT - 1 = MPCR       * JUMP TO FAULT HANDLING ROUTINE          06080000 D
                                                               *                                         06081000 D
                                                               *                                         06082000 D
                              OPCODE37:                        * NOT IMPLEMENTED                         06083000 D
12A5  4E50 0000 0000 0040               NOTIMP - 1 = MPCR                                                06084000 D
                                                               *                                         06085000 D
                              OPCODE40:                        * THIS ROUTINE ANALYZES THE 40 OPCODE     06086000 D
12A6  5F90 0000 0000 006C               XFCODE - 1 = CPCR      * :F: FIELD RETURNED IN A2                06087000 D
12A7  4809 C0D2 0C0C C0FC               A2 EQL 1                                                         06088000 D
12A8  6806 0000 0000 C0F0               IF TRUE THEN STEP ELSE SKIP                                      06089000 D
12A9  1AEC 0000 0000 C040               OP401 - 1 = MPCR       * SPECIAL CASE 401                        06090000 D
12AA  4809 0C40 8BPC DCFC               B R = B                * ISOLATE THE :A: FIELD                   06091000 D
12AB  90FC 0C00 CC00 C080               4 = SAR; 15 = LIT                                                06092000 D
12AC  4809 2C56 2B00 00FC               LIT AND B = B,A2       * B AND A2 = :A: FIELD                    06093000 D
12AD  4809 2C5E 0000 0CF0               LIT GEQ B                                                        06094000 D
12AE  00C0 0000 0C0C C0E0               12 = LIT               * TEST FOR NOT ASSIGNED INST.             06095000 D
12AF  7819 0000 C000 C0F0               IF TRUE THEN SKIP                                                06096000 D
12B0  3C0C C000 0000 0040               FAULT - 1 = MPCR                                                 06097000 D
12B1  4809 C640 004C 00F0               A2 + AMPCR = AMPCR                                               06098000 D
12B2  1AFC 00C0 0000 C0C0               JUMP40 - 1 = AMPCR                                               06099000 D
12B3  4809 0000 0030 00F0               STEP                                                             06100000 D
12B4  4824 0000 0C00 00F0               EXEC                                                             06101000 D
                                                               *                                         06102000 D
12B5  180C 0CC0 0000 0040     JUMP40:   OP40X00 - 1 = MPCR                                               06103000 D
12B6  181C 0000 0000 C040               OP40X01 - 1 = MPCR                                               06104000 D
12B7  182C 0000 0000 C040               OP40X02 - 1 = MPCR                                               06105000 D
12B8  1830 0000 0000 0040               OP40X03 - 1 = MPCR                                               06106000 D
12B9  1840 0000 CC00 C040               OP40X04 - 1 = MPCR                                               06107000 D
12BA  185C 00C0 0000 004C               OP40X05 - 1 = MPCR                                               06108000 D
12BB  4E5C 00C0 0C0C 0040               NOTIMP - 1 = MPCR                                                06109000 D
12BC  4E5C 00C0 C000 C040               NOTIMP - 1 = MPCR                                                06110000 D
12BD  186C 00C0 0000 0040               OP40X10 - 1 = MPCR                                               06111000 D
12BE  187C 0CC0 000C C040               OP40X11 - 1 = MPCR                                               06112000 D
12BF  1880 0000 0000 C040               OP40X12 - 1 = MPCR                                               06113000 D
12C0  1890 0000 0000 C040               OP40X13 - 1 = MPCR                                               06114000 D
                                                               *                                         06115000 D
                              OP40X00:                         * CC INDICATES = OR 0; JUMP EQUAL         06116000 D
12C1  226C 0000 0000 0060               CHECKCC - 1 = CPCR     * CC RETURNED IN B                        06117000 D
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12C2  4809 0C52 0000 00F0            0 EQL B                                                      06118000 D
12C3  63C9 0000 0000 00F0            IF FALSE THEN SET LC1                                        06119000 D
12C4  18AC 0000 0000 0040            OP40X - 1 = MPCR                                             06120000 D
                                                           %                                      06121000 D
                           OP40X01:                        % CC NOT EQUAL OR NOT 0; JUMP NOT EQUAL 06122000 D
12C5  2260 0000 0000 0060            CHECKCC - 1 = CPCR                                           06123000 D
12C6  4809 0C5E 0000 00F0            0 GTR 0                                                      06124000 D
12C7  78C9 0000 0000 C0F0            IF FALSE THEN SET LC1                                        06125000 D
12C8  180C 0000 0000 0040            OP40X - 1 = MPCR                                             06126000 D
                                                           %                                      06127000 D
                           OP40X02:                        % CC >= OR + ; JUMP GTR OR EQUAL       06128000 D
12C9  2260 0000 0000 0060            CHECKCC - 1 = CPCR                                           06129000 D
12CA  4809 2C5E 0000 00F0            LIT GEQ B                                                    06130000 D
12CB  0C2C 0000 0000 00E0            2 = LIT                                                      06131000 D
12CC  73C9 0000 0000 C0F0            IF FALSE THEN SET LC1                                        06132000 D
12CD  10CC 0000 0000 0040            OP40X - 1 = MPCR                                             06133000 D
                                                           %                                      06134000 D
                           OP40X03:                        % CC < OR -; JUMP LESS                 06135000 D
12CE  2260 0000 0000 0060            CHECKCC - 1 = CPCR                                           06136000 D
12CF  48C9 2C52 0000 00F0            LIT EQL E                                                    06137000 D
12D0  0C30 0000 0000 C0E0            3 = LIT                                                      06138000 D
12D1  53C9 0000 0000 C0F0            IF FALSE THEN SET LC1                                        06139000 D
12D2  1800 0000 0000 C040            OP40X - 1 = MPCR                                             06140000 D
                                                           %                                      06141000 D
                           OP40X04:                        % IF OVERFLOW SET, JUMP; JUMP OVERFLOW 06142000 D
12D3  4809 A000 A000 C0F0            A1 R = A2                                                    06143000 D
12D4  3000 0000 0000 0C3C            27 = SAR                                                     06144000 D
12D5  4809 C000 0000 00F0            A2                                                           06145000 D
12D6  53C9 0000 0C00 C0F0            IF NOT LST THEN SET LC1                                      06146000 D
12D7  18EC C000 C000 0040            OP40X - 1 = MPCR                                             06147000 D
                                                           %                                      06148000 D
                           OP40X05:                        % IF CARRY; JUMP CARRY                 06149000 D
12D8  4009 A000 A000 00F0            A1 R = A2                                                    06150000 D
12D9  8000 0000 0000 C030            28 = SAR                                                     06151000 D
12DA  4809 C000 0000 C0F0            A2                                                           06152000 D
12DB  53C9 0000 0000 00FC            IF NOT LST THEN SET LC1                                      06153000 D
12DC  18F0 0000 0000 C040            OP40X - 1 = MPCR                                             06154000 D
                                                           %                                      06155000 D
                           OP40X10:                        % JUMP                                 06156000 D
12DD  1C00 0000 0000 C04C            OP40X - 1 = MPCR                                             06157000 D
                                                           %                                      06158000 D
                           OP40X11:                        % JUMP AFTER STOP                      06159000 D
12DE  48CC C000 0000 C0F0            WAIT                  % MACHINE STOPS                        06160000 D
12DF  4809 0000 0000 00F0            STEP                                                         06161000 D
12E0  1C10 0000 0000 0040            OP40X - 1 = MPCR                                             06162000 D
                                                           %                                      06163000 D
                           OP40X12:                        % IF KEY 1 SET, STOP. JUMP.            06164000 D
12E1  4809 A000 A000 C0F0            A1 R = A2                                                    06165000 D
12E2  9000 0000 0000 C03C            29 = SAR                                                     06166000 D
12E3  4809 C000 C000 00F0            A2                                                           06167000 D
12E4  53CB 0000 C000 00F0            IF NOT LST THEN SET LC1 ELSE SKIP                            06168000 D
12E5  1C20 0000 0000 0040            OP40X - 1 = MPCR                                             06169000 D
12E6  4800 0000 0000 C0F0            WAIT                  % MACHINE STOPS                        06170000 D
12E7  4809 0000 0000 0CF0            STEP                                                         06171000 D
12E8  1C30 0000 0000 C04C            OP40X - 1 = MPCR                                             06172000 D
                                                           %                                      06173000 D
                           OP40X13:                        % IF KEY 2 SET, STOP. JUMP             06174000 D
12E9  4809 A000 A000 C0F0            A1 R = A2                                                    06175000 D
12EA  A000 0000 0000 C030            30 = SAR                                                     06176000 D
12EB  4809 C000 0000 00F0            A2                                                           06177000 D
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12EC  53C8 0000 000C C0F0            IF NOT LST THEN SET LC1 ELSE SKIP                          06178000 D
12ED  5819 0000 0000 C0F0            IF LST THEN SKIP                                           06179000 D
12EE  1C40 0000 0000 0040            OP40X - 1 = MPCR                                           06180000 D
12EF  4800 0000 0000 C0F0            WAIT                      % MACHINE STOPS                  06181000 D
12F0  4809 0000 0000 00F0            STEP                                                       06182000 D
12F1  1C50 0000 0000 C040            OP40X - 1 = MPCR                                           06183000 D
                                                               %                                06184000 D
12F2  5F90 0000 0000 0060   OP40X:   XFCODE - 1 = CPCR         % DECODE THE :F: FIELD           06185000 D
12F3  4809 C640 C000 C0FC            A2 + AMPCR = AMPCR                                         06186000 D
12F4  1C60 C000 0000 00C0            OP40F - 1 = AMPCR                                          06187000 D
12F5  4809 0000 C000 C0F0            STEP                                                       06188000 D
12F6  4024 C000 0000 00F0            EXEC                                                       06189000 D
                                                               %                                06190000 D
12F7  1C70 0000 000C 0040   OP40F:   OP400 - 1 = MPCR                                           06191000 D
12F8  3000 0000 0000 004C            FAULT - 1 = MPCR          % DECODING PROBLEM               06192000 D
12F9  1C8C C000 0000 C040            OP402 - 1 = MPCR                                           06193000 D
12FA  1C90 0000 0000 0040            OP403 - 1 = MPCR                                           06194000 D
                                                               %                                06195000 D
                            OP400:                             % THIS ROUTINE LOADS (R(M)) INTO P.  06196000 D
                                                               % TYPE RR                        06197000 D
12FB  280B 0000 C000 00F0            IF LC1 THEN STEP ELSE SKIP  % ABORT JUMP, GET NEXT INST.   06198000 D
12FC  66E0 0000 0000 004C            OPCODE - 1 = MPCR                                          06199000 D
12FD  4809 E155 0B0C 00FC            A3 AND LIT = B            % B = :M: FIELD                  06200000 D
12FE  00FC 0000 0000 C0EC            15 = LIT                                                   06201000 D
12FF  51CC 0000 0000 0060            REGSTACK - 1 = CFCR                                        06202000 D
1300  2F3C 0000 0000 0060            EINPUT - 1 = CPCR         % B = (R(M))                     06203000 D
1301  4809 A000 C000 00FC            A1 R = A1                                                  06204000 D
1302  0C00 0000 0000 C020            16 = SAR                                                   06205000 D
1303  4809 A0C1 4000 C0F0            A1 L = A1                                                  06206000 D
1304  4809 AC5C 4000 C0F0            A1 OR B = A1              % (R(M)) -> P                    06207000 D
1305  56E0 C000 0000 004C            OPCODE - 1 = MPCR                                          06208000 D
                                                               %                                06209000 D
                            OP402:                             % THIS ROUTINE LOADS Y INTO P. TYPE RK  06210000 D
1306  28CB C000 0000 C0F0            IF LC1 THEN STEP ELSE SKIP  % ABORT JUMP, GET NEXT INST.   06211000 D
1307  1D3C C000 0000 0040            BUMP - 1 = MPCR                                            06212000 D
1308  4809 E155 0B0C C0F0            A3 AND LIT = B                                             06213000 D
1309  00FC C000 0000 C0E0            15 = LIT                                                   06214000 D
130A  4809 0C52 0000 00F0            0 EOL B                                                    06215000 D
130B  6A49 0000 0000 00FC            IF TRUE THEN SET LC2                                       06216000 D
130C  51CC 0000 0000 0060            REGSTACK - 1 = CPCR                                        06217000 D
130D  2F30 0000 000C 006C            EINPUT - 1 = CPCR         % B = (R(M))                     06218000 D
130E  4809 0C4D 100C C0F0            B = A3                    % A3 = (R(M))                    06219000 D
130F  633C C000 000C 0060            IFETCH - 1 = CPCR         % B = :Y:                        06220000 D
1310  3819 0000 0000 00FC            IF LC2 THEN SKIP                                           06221000 D
1311  280B C000 0000 00F0            IF LC1 THEN STEP ELSE SKIP  % ABORT JUMP, GET NEXT INST.   06222000 D
1312  1D30 0000 0000 0040            BUMP - 1 = MPCR                                            06223000 D
1313  4809 EC4D CB0C C0FC            A3 + B = B                % (R(M)) + :Y: = Y               06224000 D
1314  4809 A000 C00C C0F0            A1 R = A1                                                  06225000 D
1315  D0CC 0000 C000 C020            16 = SAR                                                   06226000 D
1316  4809 AD01 400C C0FC            A1 L = A1                                                  06227000 D
1317  4809 AC5C 4000 C0FC            A1 OR B = A1              % Y INTO PAR                     06228000 D
1318  66E0 0000 000C 0040            OPCODE - 1 = MPCR                                          06229000 D
                                                               %                                06230000 D
                            OP403:                             % THIS ROUTINE LOADS Y INTO P.   06231000 D
                                                               % TYPE RX.                       06232000 D
1319  5700 0000 0000 C060            RXMFIELD - 1 = CFCR       % B = Y                          06233000 D
131A  4809 CC41 0010 00F0            B L = BR2                                                  06234000 D
131B  000C C0C0 C000 0030            COMP B = SAR                                               06235000 D
131C  50E0 0000 C000 0060            EMULIN - 1 = CPCR         % B = (Y)                        06236000 D
131D  4809 A000 C000 C0FC            A1 R = A1                                                  06237000 D
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131E  0000 0000 0000 0020           16 = SAR
131F  4809 AC01 4000 00F0           A1 L = A1
1320  4809 AC5C 4C00 00F0           A1 OR D = A1          % (Y) INTO PAR
1321  66E0 0000 0000 C040           OPCODE - 1 = MPCR
                                                          %
                          OP401:                          % LJ; LOCAL JUMP
                                                          % (P) + XD -> F
                                                          % TYPE RI (1)
1322  559C 0000 0000 004C           RI1 - 1 = MPCR        % (P) + XD -> P
                                                          %
                                                          %
                          OPCODE41:                       % INDEX JUMP
1323  5F90 0000 0000 0060           XFCODE - 1 = CPCR     % "F" CODE RETURNED IN A2
1324  4809 C640 0040 C0FC           A2 + AMPCR = AMPCR
1325  1CAC 0003 C000 00C0           OP41F - 1 = AMPCR
1326  4009 0000 C00C C0F0           STEP
1327  4824 0003 0000 C0FC           EXEC
                                                          %
                                                          %
1328  1C80 0000 000C 0040 OP41F:    OP410 - 1 = MPCR
1329  1CCC 0000 0000 0040           OP411 - 1 = MPCR
132A  1CDC 0000 000C C04C           OP412 - 1 = MPCR
132B  1CEC 0000 000C 0040           OP413 - 1 = MPCR
                                                          %
                                                          %
                          OP410:                          % RR TYPE INDEX JUMP
                                                          % IF (R(A)) NE 0, (R(A)) - 1 INTO R(A)
                                                          % AND (R(M)) IN P
132C  2260 0000 0000 C060           CONTENTSRA - 1 = CFCR % RETURN (R(A)) IN B
132D  4809 0C52 C000 00F0           D EOL 0
132E  680B 0000 000C 00F0           IF TRUE THEN STEF ELSE SKIP
132F  56EC 0000 0000 0040           OPCODE - 1 = MPCR
1330  4809 0C40 200C 00F0           B = A2
1331  4809 CDDE 003C C0F0           A2 - 1 = MIR          % DECREMENT (R(A))
1332  2F50 0000 0000 0060           EOUTPUT - 1  = CPCR   % WRITE NEW (R(A)) VALUE IN R(A)
1333  2380 C000 C000 0060           CONTENTSRM - 1 = CPCR % B CONTAINS (R(M))
1334  4809 AC00 C000 C0F0           A1 R = A1             % CLEAR THE OLD PAR
1335  0000 C000 000C C020           16 = SAR
1336  4809 AC01 4000 00F0           A1 L = A1
1337  4809 AC5C 400C 00F0           A1 OR B = A1          % CREATE NEW PAR
1338  56EC C000 0000 0040           OPCODE - 1 = MPCR
                                                          %
                                                          %
                          OP411:                          % RI TYPE 1, LOCAL JUMF INDIRECT
                                                          % IF (CC) NE C, ((P) + D) INTO P
1339  226C 0000 000C 0060           CHECKCC - 1 = CPCR    % FUT (CC) INTO LS 2 DITS CF B
133A  4809 CC52 000C C0FC           B EOL 0
133B  680B 0000 000C C0F0           IF TRUE THEN STEF ELSE SKIP
133C  56E0 0000 0000 0040           OPCODE - 1 = MPCR
133D  5590 0000 C000 C04C           RI1 - 1 = MPCR        % (P) + D = P
                                                          %
                                                          %
                          OP412:                          % PK TYPE INDEX JUMP
                                                          % IF (R(A)) NE 0, (R(A)) - 1 INTO R(A),
                                                          % Y INTO P
133E  2290 C000 C000 0060           CONTENTSRA - 1 = CFCR % PUT (R(A)) IN B
133F  4809 0C52 C000 00FC           B EOL C
1340  680B 0000 C00C C0FC           IF TRUE THEN STEF ELSE SKIP
1341  66EC 0000 000C C040           OPCODE - 1 = MPCR
1342  4809 0C40 200C C0FC           B = A2
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1343  4809 C0DE C090 C0F0            A2 - 1 = MIR               * DECREMENT (R(A))                                  06298000 D
1344  4809 E0C0 8C1C 00F0            A3 R = MAR2                * ADDRESS OF R(A) INTO MAR2                         06299000 D
1345  0000 0C00 CC30 0020            16 = SAR                                                                       06300000 D
1346  2F5C 0000 C000 0060            EOUTPUT - 1 = CPCR         * (R(A)) - 1  INTO R(A)                             06301000 D
1347  4809 E155 1000 C0F0            A3 AND LIT = A3            * "M" FIELD IN A3                                   06302000 D
1348  00FC 00C0 0000 00E0            15 = LIT                                                                       06303000 D
1349  4809 E012 0030 00F0            A3 EQL 0                                                                       06304000 D
134A  6C19 C000 0000 00F0            IF TRUE THEN 0 = D; SKIP                                                       06305000 D
134B  238C 00C0 C000 006C            CONTENTSRM - 1 = CPCR      * RETURN (R(M)) IN D                                06306000 D
134C  4809 0C40 1000 00FC            D = A3                     * STORE (R(M)) OR C IN A3                           06307000 D
134D  633C 0C00 C000 006C            IFETCH - 1 = CPCR          * PUT Y IN B                                        06308000 D
134E  4809 EC40 C000 00F0            A3 + B = B                 * Y INTO B                                          06309000 D
134F  4809 A000 C000 C0F0            A1 R = A1                                                                      06310000 D
1350  0000 00C0 0030 0020            COMP 16 = SAR                                                                  06311000 D
1351  4809 A0C1 4C0C C0FC            A1 L = A1                                                                      06312000 D
1352  4809 AC5C 4000 00F0            A1 OR D = A1                                                                   06313000 D
1353  56EC 0000 0C00 0040            OPCODE - 1 = MPCR                                                              06314000 D
                                                                *                                                   06315000 D
                                                                *                                                   06316000 D
                            OP413:                              * RX TYPE INDEX JUMP                                06317000 D
                                                                * IF (R(A)) NE 0, (R(A)) - 1 = (R(A)),              06318000 D
                                                                * (Y) INTO P                                        06319000 D
1354  4809 E000 8B30 00FC            A3 R = B                   * SHIFT A3 TO OBTAIN "A"                            06320000 D
1355  80F0 C0C0 0000 008C            4 = SAR; 15 = LIT                                                              06321000 D
1356  4809 2C56 0B30 00F0            LIT AND B = B              * ISOLATE "A"                                       06322000 D
1357  51CC 0CC0 0030 0060            REGSTACK - 1 = CPCR        * R(A) INTO MAR2                                    06323000 D
1358  2F3C 00C0 0030 C060            EINPUT - 1 = CPCR          * (R(A)) INTO B                                     06324000 D
1359  4809 0C52 0C0C C0F0            B EQL C                                                                        06325000 D
135A  58CB C000 C000 C0F0            IF TRUE THEN STEP ELSE SKIP                                                    06326000 D
135B  1030 00C0 0000 0040            BUMP - 1 = MPCR            * ADVANCE THE PAR BY 1 AND CALL OPCODE              06327000 D
135C  4809 0C40 2000 00FC            B = A2                                                                         06328000 D
135D  4809 C0DE C090 00FC            A2 - 1 = MIR               * DECREMENT (R(A))                                  06329000 D
135E  2F50 0000 0C0C C060            EOUTPUT - 1 = CPCR         * OUTPUT NEW VALUE OF R(A) IN R(A)                  06330000 D
135F  4809 EC00 0B00 00F0            A3 = B                     * RESTORE INSTRUCTION IN B                          06331000 D
1360  5700 0CC0 0030 0060            RXMFIELD - 1 = CPCR        * ANALYZE THE "M" FIELD                             06332000 D
1361  4809 0C41 0010 00FC            B L = BR2                  * ADDRESS OF Y IN BR2                               06333000 D
1362  0CCC CC00 C030 C03C            COMP 8 = SAR                                                                   06334000 D
1363  60EC C0C0 0000 C060            EMULIN - 1 = CPCF          * (Y) INTO B                                        06335000 D
1364  4809 A0C0 C000 00F0            A1 R = A1                  * CLEAR OLD PAR                                     06336000 D
1365  000C 00C0 0000 0020            COMP 16 = SAR                                                                  06337000 D
1366  4809 ACC1 4C0C C0F0            A1 L = A1                                                                      06338000 D
1367  4809 AC5C 4C00 0CFC            A1 OR B = A1               * CREATE NEW PAR                                    06339000 D
1368  66E0 0CC0 C00C C040            OPCODE - 1 = MPCR                                                              06340000 D
                                                                *                                                   06341000 D
                                                                *                                                   06342000 D
                            OPCODE42:                           * RR TYPE JUMP, LINK REGISTERS                      06343000 D
1369  5F90 00C0 0C30 C060            XFCODE - 1 = CPCR          * "F" INTO A2                                       06344000 D
136A  4809 C640 0C4C 00F0            A2 + AMPCR = AMPCR                                                             06345000 D
136B  1CF0 00C0 000C 00C0            OP42F - 1 = AMPCR                                                              06346000 D
136C  4809 CCC0 0C0C 00FC            STEP                                                                           06347000 D
136D  4824 C0C0 C000 00F0            EXEC                                                                           06348000 D
                                                                *                                                   06349000 D
                                                                *                                                   06350000 D
136E  100C 0CC0 000C 004C   OP42F:   OP420 - 1 = MPCR                                                               06351000 D
136F  3000 0000 0C0C C040            FAULT - 1 = MPCR                                                               06352000 D
1370  101C 0000 0000 C04C            OP422 - 1 = MPCR                                                               06353000 D
1371  102C 00C0 0C0C C040            OP423 - 1 = MPCR                                                               06354000 D
                                                                *                                                   06355000 D
                                                                *                                                   06356000 D
                            OP420:                              * JUMP, LINK REGISTER                               06357000 D
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                                                          % (P) + 1 INTO R(A); (R(M)) INTO P    06358C0C D
1372  4809 0C40 8B0C C0F0            B R = B                                                  06359C0C D
1373  90FC 0CC0 C0DC 008C            4 = SAR; 15 = LIT                                        06360C00 D
1374  4809 2C56 0B0C C0FC            LIT AND B = B           % B CONTAINS "A"                 06361C00 D
1375  51C0 00C0 0C00 006C            REGSTACK - 1 = CPCR     % ADDRESS OF R(A) IN MAR2        06362C00 D
1376  4809 A001 2C00 C0F0            A1 L = A2               % (P) INTO MS WORD OF A2         06363C0C D
1377  000C 0000 0000 0020            16 = SAR                                                 06364C00 D
1378  4809 CCC0 AC00 00FC            A2 R = A2               % (P) INTO LS WORD OF A2         06365CC0 D
1379  4009 C0C0 003C 00F0            A2 + 1 = MIR            % (P) + 1 INTO MIR               06366C00 C
137A  2F5C 0000 0C00 0060            EOUTPUT - 1 = CPCR      % (P) + 1 INTO R(A)              06367C00 D
137B  2380 C003 C000 C06C            CONTENTSRM - 1 = CPCR   % (R(M)) INTO B                  06368C00 D
137C  4009 AC00 CC0C C0F0            A1 R = A1               % CLEAR PAR FIELD                06369C00 D
137D  000C C000 0C00 C020            COMP 16 = SAR                                            06370C00 D
137E  4809 A0C1 4C0C C0F0            A1 L = A1               % PREPARE FOR NEW PAR            06371000 D
137F  4809 AC5C 4000 00F0            A1 OR B = A1            % CREATE NEW PAR                 06372C00 D
1380  66EC 00C0 0000 C040            OPCODE - 1 = MPCR                                        06373C00 D
                                                          %                                     06374C00 D
                                                          %                                     06375C00 D
                       OP422:                             % RK TYPE JUMP, LINK REGISTERS        06376C00 D
                                                          % (P) + 2 INTO R(A); Y INTO P         06377000 D
1381  4809 0C40 8B0C 00FC            0 R = B                                                  06378C00 C
1382  80F0 0C03 000C C08C            4 = SAR; 15 = LIT                                        06379CC0 D
1383  4809 2C56 0B0C C0FC            LIT AND D = B           % B CONTAINS "A"                 06380C00 D
1384  51C0 C0C0 0C00 0060            REGSTACK - 1 = CPCR     % MAR2 CONTAINS ADDRESS OF R(A)  06381000 D
1385  4809 A0C1 203C 00F0            A1 L = A2               % SAVE OLD PAR                   06382C00 D
1386  0020 0C00 0C0C C0A0            COMP 16 = SAR; 2 = LIT                                   06383C00 D
1387  4809 C0C0 AC0C 00F0            A2 R = A2               % PAR INTO LS WORD OF A2         06384C0C D
1388  4809 C140 0C30 C0F0            A2 + LIT = MIR          % MIR CONTAINS (P) + 2           06385C00 D
1389  2F5C C0C0 0C70 006C            EOUTPUT - 1 = CPCR      % PUT (P) + 2 INTO R(A)          06386C00 C
138A  4809 E156 10DC 00FC            A3 AND LIT = A3         % "M" INTO A3                    06387C00 D
138B  00FC 0CC0 0C3C C0E0            15 = LIT                                                 06388000 D
138C  4809 E012 0C00 C0F0            A3 EQL C                                                 06389000 D
138D  6C19 0000 0B0C 00FC            IF TRUE THEN 0 = D; SKIP  % CHECK IF "M" = 0             06390C00 D
138E  238C 0000 C000 0060            CONTENTSRM - 1 = CPCR  % (R(M)) INTO B                   06391C00 D
138F  4809 0C40 10CC 00F0            B = A3                                                   06392C00 D
1390  633C 0000 C00C 0C60            IFETCH - 1 = CPCR       % Y INTO B                       06393C0C D
1391  4809 EC40 CB0C 00F0            A3 + B = B              % (Y) INTO B                     06394C00 D
1392  4809 AC03 CC00 C0F0            A1 R = A1               % CLEAR THE PAR                  06395C00 D
1393  0000 0CC0 0C00 C020            COMP 16 = SAR                                            06396C00 D
1394  4809 AC C1 4000 00F0           A1 L = A1               % PREPARE FOR THE NEW PAR        06397C00 D
1395  4809 AC5C 4CC0 0CF0            A1 OR D = A1            % CREATE THE NEW PAR             06398C00 D
1396  56E0 0000 0C00 C04C            OPCODE - 1 = MPCR                                        06399C0C D
                                                          %                                     06400C00 D
                                                          %                                     06401C00 D
                       OP423:                             % RX TYPE JUMP, LINK REGISTERS        06402C00 D
                                                          % (P) + 2 INTO R(A); (Y) INTO P       06403C0C D
1397  4809 0C40 9B0C 00FC            B R = B                                                  06404C00 D
1398  80FC C000 0C00 0080            4 = SAR; 15 = LIT                                        06405C00 D
1399  4809 2C56 CB00 C0F0            LIT AND B = F           % B CONTAINS "A"                 06406000 D
139A  51C0 0CC3 C030 C060            REGSTACK - 1 = CPCR     % ADDRESS OF R(A) IN MAR2        06407C0C D
139B  4809 A0C1 20CC C0FC            A1 L = A2               % (P) INTO MS WORD OF A2         06408CC0 D
139C  002C C000 CC3C 00A0            16 = SAR; 2 = LIT                                        06409C0C D
139D  4809 C0C0 A0C0 00F0            A2 R = A2               % (P) INTO LS WORD OF A2         06410C000 D
139E  4809 C140 0030 CCF0            A2 + LIT = MIR          % (P) + 2 INTO MIR               06411C00 D
139F  2F5C C0C0 0C0C C060            EOUTPUT - 1 = CPCR      % (P) + 2 INTO R(A)              06412C0C C
13A0  4809 C0C0 0B0C 00F0            A3 = B                  % SET UP D FOR RXMFIELD          06413C0C D
13A1  57CC 0000 000C 0060            RXMFIELD - 1 = CPCR     % Y INTO B                       06414C00 D
13A2  4809 0C41 0C10 00FC            B L = BR2               % Y INTO BR2                     06415000 D
13A3  00CC C0C0 000C C030            COMP 8 = SAR                                             06416C0C D
13A4  60E0 00C0 0C00 C060            EMULIN - 1 = CPCR       % (Y) INTO B                     06417C0C D
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13A5  4809 A0C0 C000 00F0                A1 R = A1                  % CLEAR THE OLD PAR                       06418000 D
13A6  0000 C000 0000 0020                COMP 16 = SAR                                                        06419000 D
13A7  4809 A0C1 4000 C0F0                A1 L = A1                  % PREPARE TO RECEIVE NEW PAR              06420000 D
13A8  4809 AC5C 4000 C0F0                A1 OR B = A1               % CREATE NEW PAR                          06421000 D
13A9  66E0 0000 C000 C040                OPCODE - 1 = MPCR                                                    06422000 D
                                                                    %                                         06423000 D
                                                                    %                                         06424000 D
                              OPCODE43:                             % JUMP, LINK MEMORY                       06425000 D
13AA  5F90 0CC0 0C00 0060                XFCODE - 1 = CPCR          % "F" RETURNED IN A2                      06426000 D
13AB  4809 C640 C090 C0F0                A2 + AMPCR = AMPCR                                                   06427000 D
13AC  103C 0000 0000 00C0                OP43F - 1 = AMPCR                                                    06428000 D
13AD  4809 0000 0C0C C0F0                STEP                                                                 06429000 D
13AE  4824 0C00 0C00 00FC                EXEC                                                                 06430000 D
                                                                    %                                         06431000 D
                                                                    %                                         06432000 D
13AF  3000 0000 0000 0040     OP43F:     FAULT - 1 = MPCR                                                     06433000 D
13B0  1040 0000 0000 C040                OP431 - 1 = MPCR                                                     06434000 D
13B1  1050 0C00 0C00 C040                OP432 - 1 = MPCR                                                     06435000 D
13B2  1060 CC00 0000 0040                OP433 - 1 = MPCR                                                     06436000 D
                                                                    %                                         06437000 D
                                                                    %                                         06438000 D
                              OP431:                                % RI TYPE 1, LOCAL JUMP, LINK MEMORY      06439000 D
                                                                    % ONLY EXECUTE IF CC = 0                  06440000 D
13B3  2260 00C0 C000 C060                CHECKCC - 1 = CPCR         % CHECK THE CC CODE                       06441000 D
13B4  4809 0C52 0000 C0F0                0 EOL B                    % CHECK IF CC = 0                         06442000 D
13B5  6819 0000 0000 00F0                IF TRUE THEN SKIP                                                    06443000 D
13B6  66E0 0000 0000 0040                OPCODE - 1 = MPCR                                                    06444000 D
13B7  2809 A0C1 2000 00F0                A1 L = A2; IF LC1          % PAR INTO A2 (MS WORD)                   06445000 D
13B8  C0CC C000 0000 0020                COMP 16 = SAR                                                        06446000 D
13B9  4809 C0C0 A000 00FC                A2 R = A2                  % PAR INTO A2 (LS WORD)                   06447000 D
13BA  4809 C0C0 0030 00F0                A2 + 1 = MIR               % (P) + 1 INTO MIR                        06448000 D
13BB  4809 C0C1 2000 C0FC                A2 L = A2                  % PAR INTO UHW                            06449000 D
13BC  4809 E000 C800 00F0                A3 = B                     % RESTORE INSTRUCTION INTO B              06450000 D
13BD  4809 CC41 0800 40FC                B L = B,CSAR               % "D" SIGN BIT IN MS BIT OF B             06451000 D
13BE  0000 0000 C000 C010                COMP 24 = SAR                                                        06452000 D
13BF  4809 0C40 000C C0FC                B                                                                    06453000 D
13C0  4FC9 CC5E C800 C0FC                IF MST THEN - B = B; SET LC1  % IF "D" NEGATIVE SET LC1              06454000 D
13C1  4809 0C40 8800 C0FC                B R = B                    % "D" MAGNITUDE IN LSB OF B               06455000 D
13C2  4809 2C57 0800 C0F0                LIT AND B L = B            % "D" MAGNITUDE IN B                      06456000 D
13C3  07FC 0000 0000 00A0                127 = LIT; COMP 16 = SAR                                             06457000 D
13C4  4809 C000 0000 00F0                STEP                                                                 06458000 D
13C5  0C00 0000 0000 C01C                8 = SAR                                                              06459000 D
13C6  2C19 CC5E 9010 C0F0                IF LC1 THEN A2 - B R = BR2,A3; SKIP  % (P) - D                       06460000 D
13C7  4809 CC40 9C10 C0FC                A2 + B R = BR2,A3          % (P) + D                                 06461000 D
13C8  61E0 0000 000C 0060                EMULOUT - 1 = CPCR         % (P) + 1 INTO (P) + D                    06462000 D
13C9  4809 E000 8B00 C0F0                A3 R = B                                                             06463000 D
13CA  0000 00C0 C000 C010                8 = SAR                                                              06464000 D
13CB  4809 CC46 CB0C 00F0                B + 1 = B                  % (P) + D + 1 INTO B                      06465000 D
13CC  4809 A0C0 C000 00F0                A1 R = A1                  % CLEAR OLD PAR                           06466000 D
13CD  0000 0000 0000 0020                COMP 16 = SAR                                                        06467000 D
13CE  4809 AC01 400C 00F0                A1 L = A1                                                            06468000 D
13CF  4809 AC5C 4000 00F0                A1 OR B = A1               % CREATE NEW PAR                          06469000 D
13D0  66E0 0000 0000 004C                OPCODE - 1 = MPCR                                                    06470000 D
                                                                    %                                         06471000 D
                                                                    %                                         06472000 D
                              OP432:                                % RK TYPE JUMP, LINK MEMORY               06473000 D
                                                                    % (P) + 2 INTO Y; Y + 1 INTO P            06474000 D
13D1  4809 2C56 0800 00F0                LIT AND B = B              % ISOLATE "M" FIELD                       06475000 D
13D2  00FC 00C0 0000 00E0                15 = LIT                                                             06476000 D
13D3  4809 0C52 0000 00F0                B EOL 0                    % IS "M" = 0 ?                            06477000 D
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13D4   6819 00C0 0000 C0F0           IF TRUE THEN SKIP                                          06478000 D
13D5   2380 00C0 0030 0060           CONTENTSRM - 1 = CPCR  % (R(M)) INTO B                     06479000 D
13D6   4809 0C40 1000 00FC           D = A3                                                     06480000 D
13D7   533C 00C0 C000 0060           IFETCH - 1 = CPCR      % Y INTO D                          06481000 D
13D8   4809 EC41 1010 00F0           A3 + B L = BR2,A3      % Y INTO BR2, A3                    06482000 D
13D9   0000 0000 0C00 C030           COMP 8 = SAR                                               06483000 D
13DA   48C9 A0C1 2000 C0FC           A1 L = A2              % (P) INTO A2                       06484000 D
13DB   002C C0C0 C000 C0A0           COMP 16 = SAR; 2 = LIT                                     06485000 D
13DC   4809 C0C0 A000 00F0           A2 R = A2              % (P) INTO LS WORD OF A2            06486000 D
13DD   4809 C140 0090 00FC           A2 + LIT = MIR         % MIR CONTAINS (P) + 2              06487000 D
13DE   51E0 0000 C000 0060           EMULOUT - 1 = CPCR     % (P) + 2 INTO Y                    06488000 D
13DF   4809 E0C0 9000 00F0           A3 R = A3              % Y INTO A3 LS WORD                 06489000 D
13E0   0000 0000 C000 C010           B = SAR                                                    06490000 D
13E1   4809 E0C0 0B00 C0F0           A3 + 1 = B             % B CONTAINS Y + 1                  06491000 D
13E2   4809 AC00 C000 00FC           A1 R = A1              % CLEAR THE PAR                     06492000 D
13E3   0000 0000 0000 0020           16 = SAR                                                   06493000 D
13E4   4809 A0C1 400C 00F0           A1 L = A1                                                  06494000 D
13E5   4809 AC5C 4000 00F0           A1 OR B = A1           % CREATE NEW PAR                    06495000 D
13E6   66E0 0000 0000 C040           OPCODE - 1 = MPCR                                          06496000 D
                                                            %                                   06497000 D
                                                            %                                   06498000 D
                             OP433:                         % RX TYPE JUMP, LINK MEMORY         06499000 D
                                                            % (P) + 2 INTO (Y); (Y) + 1 INTO P  06500000 D
                                                            % B HOLDS THE INSTRUCTION           06501000 D
13E7   570C 0000 0000 C060           RXMFIELD - 1 = CPCR    % (Y) IN B                          06502000 D
13E8   48C9 0C41 101C 00F0           B L = BR2, A3                                              06503000 D
13E9   000C 0C00 0000 C030           COMP 8 = SAR                                               06504000 D
13EA   4809 A001 200C 00F0           A1 L = A2              % PUT PAR INTO A2                   06505000 D
13EB   0020 0000 0000 00A0           COMP 16 = SAR; 2 = LIT                                     06506000 D
13EC   4809 C000 AC00 00F0           A2 R = A2              % (P) INTO A2                       06507000 D
13ED   4809 C140 C090 C0F0           A2 + LIT = MIR         % MIR CONTAINS (P) + 2              06508000 D
13EE   61EC 0000 0000 0060           EMULOUT - 1 = CPCR     % (P) + 2 INTO (Y)                  06509000 D
13EF   4809 E000 9000 C0FC           A3 R = A3              % (Y) INTO A3                       06510000 D
13F0   000C C0C0 0000 C010           8 = SAR                                                    06511000 D
13F1   4809 E0C0 0B00 00F0           A3 + 1 = B             % (Y) + 1 INTO B                    06512000 D
13F2   48C9 AC00 C000 00F0           A1 R = A1                                                  06513000 D
13F3   0C00 0C00 0000 0020           16 = SAR                                                   06514000 D
13F4   4809 A001 4000 00F0           A1 L = A1              % A1 READY TO ACCEPT NEW PAR        06515000 D
13F5   4809 AC5C 400C 00FC           A1 OR B = A1           % CREATE NEW PAR                    06516000 D
13F6   66EC 00C0 0000 C04C           OPCODE - 1 = MPCR                                          06517000 D
                                                            %                                   06518000 D
                                                            %                                   06519000 D
                             OPCODE44:                      % JUMP ZERO                         06520000 D
13F7   5F9C C000 0000 0060           XFCODE - 1 = CPCR      % RETURNS "F" CODE IN A             06521000 D
13F8   4809 C64D 0040 C0FC           A2 + AMPCR = AMPCR                                         06522000 D
13F9   1D7C 0000 0000 00C0           OP44F - 1 = AMPCR                                          06523000 D
13FA   4809 0000 0000 C0FC           STEP                                                       06524000 D
13FB   4824 0000 0000 00F0           EXEC                                                       06525000 D
                                                            %                                   06526000 D
                                                            %                                   06527000 D
13FC   1D8C 0000 0000 0040   OP44F:  OP440 - 1 = MPCR                                           06528000 D
13FD   1D90 0000 0000 C040           OP441 - 1 = MPCR                                           06529000 D
13FE   1DA0 0000 0C00 0040           OP442 - 1 = MPCR                                           06530000 D
13FF   1DB0 0000 0000 0040           OP443 - 1 = MPCR                                           06531000 D
                                                            %                                   06532000 D
                                                            %                                   06533000 D
                             OP440:                         % RR TYPE JUMP ZERO                 06534000 D
                                                            % IF (R(A)) = 0, (R(M)) IN P        06535000 D
1400   22BC C0C0 0000 C060           CONTENTSRA - 1 = CPCR  % RETURNS (R(A)) IN B               06536000 D
1401   4809 CC52 0000 C0F0           B EQL 0                                                    06537000 D
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1402  6819 0000 0000 00F0          IF TRUE THEN SKIP                                               06538000 D
1403  66E0 0000 0000 0040          OPCODE - 1 = MPCR                                               06539000 D
1404  2380 0000 0000 0060          CONTENTSRM - 1 = CPCR  % RETURNS (R(M)) IN B                    06540000 D
1405  4809 A000 C000 C0F0          A1 R = A1              % CLEAR OLD PAR                          06541000 D
1406  0000 0000 0000 0020          COMP 16 = SAR                                                   06542000 D
1407  4809 A001 4000 00F0          A1 L = A1                                                       06543000 D
1408  4809 AC5C 4000 00FC          A1 OR B = A1           % CREATE NEW PAR                         06544000 D
1409  66E0 0000 0000 0040          OPCODE - 1 = MPCR                                               06545000 D
                                                          %                                        06546000 D
                                                          %                                        06547000 D
                        OP441:                            % RI TYPE 1 LOCAL JUMP EQUAL             06548000 D
                                                          % IF (CC) = OR 0, (P) + D INTO P         06549000 D
140A  2250 0000 0000 0060          CHECKCC - 1 = CPCR     % RETURNS CC BITS IN B                   06550000 D
140B  4809 CC52 0000 00F0          B EQL 0                                                         06551000 D
140C  6819 C000 C000 00F0          IF TRUE THEN SKIP                                               06552000 D
140D  66EC C000 C000 C040          OPCODE - 1 = MPCR                                               06553000 D
140E  5590 0000 0000 0C40          RI1 - 1 = MPCR         % (P) + D = P                            06554000 D
                                                          %                                        06555000 D
                                                          %                                        06556000 D
                        OP442:                            % RK TYPE JUMP ZERO                      06557000 D
                                                          % IF (R(A)) 0, Y INTO P                  06558000 D
140F  2280 C000 0000 0060          CONTENTSRA - 1 = CPCR  % GET (R(A)) INB                         06559000 D
1410  4809 0C52 000C C0F0          B EQL 0                                                         06560000 D
1411  6819 0000 000C 00F0          IF TRUE THEN SKIP                                               06561000 D
1412  1030 0000 0000 C040          EUMP - 1 = MPCR        % ADVANCE THE PAR BY 1 AND CALL OPCODE   06562000 D
1413  4809 E156 1000 00F0          A3 AND LIT = A3        % "M" FIELD IN A3                        06563000 D
1414  00F0 0000 000C 0DEC          15 = LIT                                                        06564000 D
1415  4809 EC12 0000 C0FC          A3 EQL 0                                                        06565000 D
1416  6C19 0000 0E00 00FC          IF TRUE THEN 0 = B; SKIP                                        06566000 D
1417  2380 00C0 000C 006C          CONTENTSRM - 1 = CPCR  % RETURN (R(M)) IN B                     06567000 D
1418  4809 CC40 100C 00F0          B = A3                                                          06568000 D
1419  633C 0000 000C 0060          IFETCH - 1 = CPCR      % Y INTO B                               06569000 D
141A  4809 EC40 0B00 00FC          A3 + B = B             % PAR VALUE IN LS WORD OF E              06570000 D
141B  4809 A000 C000 C0FC          A1 R = A1              % CLEAR OLD PAR                          06571000 D
141C  0000 C000 0000 0020          COMP 16 = SAR                                                   06572000 D
141D  4809 A001 4000 C0F0          A1 L = A1                                                       06573000 D
141E  4809 AC5C 4000 00F0        . A1 OR B = A1           % CREATE NEW PAR                         06574000 D
141F  66E0 0000 0000 C040          OPCODE - 1 = MPCR                                               06575000 D
                                                          %                                        06576000 D
                                                          %                                        06577000 D
                        OP443:                            % RX TYPE JUMP ZERO                      06578000 D
                                                          % IF (R(A)) = 0, (Y) INTO P              06579000 D
1420  2260 0000 0000 C060          CONTENTSRA - 1 = CPCR  % (R(A)) INTO B                          06580000 D
1421  4809 0C52 C000 C0F0          B EQL 0                                                         06581000 D
1422  6819 0000 0000 C0F0          IF TRUE THEN SKIP                                               06582000 D
1423  103C 0000 0000 C040          BUMP - 1 = MPCR        % ADVANCE THE PAR BY 1 AND CALL OPCODE   06583000 D
1424  4809 C000 0B0C 00F0          A3 = B                                                          06584000 D
1425  5700 0000 0000 C06C          RXMFIELD - 1 = CPCR    % ANALYZE THEN "M" FIELD                 06585000 D
1426  4809 CC41 001C 00FC          B L = BR2              % PUT Y INTO BR2                         06586000 D
1427  0000 0000 C000 CC30          COMP 8 = SAR                                                    06587000 D
1428  60EC 0000 0000 C060          EMULIN - 1 = CPCR      % (Y) INTO B                             06588000 D
1429  4809 A000 C000 C0FC          A1 R = A1              % CLEAR OLD PAR                          06589000 D
142A  000C 0000 000C C020          COMP 16 = SAR                                                   06590000 D
142B  4809 AC01 4000 C0F0          A1 L = A1                                                       06591000 D
142C  4809 AC5C 4000 00F0          A1 OR B = A1           % CREATE NEW PAR                         06592000 D
142D  66E0 0000 0000 C04C          OPCODE - 1 = MPCR                                               06593000 D
                                                          %                                        06594000 D
                                                          %                                        06595000 D
                        OPCODE45:                         % JUMP NOT ZERO                          06596000 D
142E  5F90 C000 0000 0060          XFCODE - 1 = CPCR      % RETURN "F" FIELD IN LSD OF A2          06597000 D
```

```
142F  4809 C640 0040 00F0              A2 + AMPCR = AMPCR
1430  10C0 C000 0000 00C0              OP45F - 1 = AMPCR
1431  4809 0000 0000 C0F0              STEP
1432  4824 00C0 0000 C0F0              EXEC
                                                                 %
                                                                 %
1433  10DC C000 C000 C040   OP45F:     OP45C - 1 = MPCR
1434  10E0 00C0 0C00 004C              OP451 - 1 = MPCR
1435  10FC 0000 0030 C040              OP452 - 1 = MPCR
1436  1E0C C003 0C30 C040              OP453 - 1 = MPCR
                                                                 %
                                                                 %
                            OP450:                               % RR TYPE JUMP NOT ZERO
                                                                 % IF (R(A)) NE 0, (R(M)) INTO P
1437  22BC 0000 0C30 006C              CONTENTSRA - 1 = CPCR   % (R(A)) INTO B
1438  4809 0C52 C000 00F0              B EOL 0
1439  580E 00C0 C030 00F0              IF TRUE THEN STEP ELSE SKIP
143A  56E0 0CC0 00DC 0040              OPCODE - 1 = MPCR
143B  238C 0CC0 0C30 0060              CONTENTSRM - 1 = CPCR  % RETURN (R(M)) IN B
143C  4809 A000 CC3C 00F0              A1 R = A1
143D  0000 000D 0C3C 0020              COMP 16 = SAR
143E  4809 A0C1 400C 00F0              A1 L = A1                 % A1 PAR FIELD CLEARED
143F  4809 AC5C 4000 C0FC              A1 OR B = A1              % CREATE NEW PAR
1440  56E0 C0C0 C000 C040              OPCODE - 1 = MPCR
                                                                 %
                                                                 %
                            OP451:                               % RI TYPE JUMP NOT EQUAL
                                                                 % IF (CC) NE, (P) + D INTO P
1441  226C 00C0 CC0C C060              CHECKCC - 1 = CPCR        % PUT CC BITS IN B
1442  4809 0C52 0030 CCF0              B EOL 0
1443  6806 0000 CC3C C0F0              IF TRUE THEN STEP ELSE SKIP
1444  66EC 00C0 CC30 004C              OPCODE - 1 = MPCR
1445  5590 000C 000C C040              RI1 - 1 = MPCR            % (P) + D = P
                                                                 %
                                                                 %
                            OP452:                               % RK TYPE JUMP NOT ZERO
                                                                 % IF (R(A)) NE 0, Y INTO P
1446  2280 00C3 0000 C060              CONTENTSRA - 1 = CPCR  % (R(A)) INTO B
1447  4809 0C52 C03C C0F0              B EOL 0
1448  680E 00C0 CC30 C0F0              IF TRUE THEN STEF ELSE SKIP
1449  103C C0C0 0000 0040              BUMP - 1 = MPCR           % ADVANCE THE PAR BY 1 AND CALL OPCODE
144A  4809 E155 1030 C0F0              A3 AND LIT = A3           % "M" FIELD IN A3
144B  00FC C0C0 0030 00E0              15 = LIT
144C  4809 EC12 0C0C 00F0              A3 EOL 0
144D  6C19 000C 0BDC C0F0              IF TRUE THEN 0 = B; SKIP
144E  238C 0000 000C 0060              CONTENTSRM - 1 = CPCR  % (R(M)) IN B
144F  4809 CC40 1030 00F0              P = A3
1450  533C C0C0 000C C060              IFETCH - 1 = CPCR         % PUT Y INTO B
1451  4809 EC40 0B00 00F0              A3 + B = B
1452  4609 A0C3 C030 00F0              A1 R = A1
1453  0000 C0C0 0030 002C              COMP 16 = SAR
1454  4809 A001 400C C0FC              A1 L = A1
1455  48C9 AC5C 4000 00F0              A1 OR D = A1              % CREATE NEW PAR
1456  56EC 00C0 0C30 0040              OPCODE - 1 = MPCR
                                                                 %
                                                                 %
                            OF453:                               % RX TYPE JUMP NOT ZERO
                                                                 % IF (R(A)) NE 0, (Y) INTO P
1457  4809 CC40 8B0C 00F0              B R = B                   % SHIFT "A" TO LS BITS
1458  8CFC C003 0CC0 C080              4 = SAR; 15 = LIT
```

```
1459  4809 2C56 0600 00F0            LIT AND B = B            % ISOLATE "A"
145A  51C0 0000 0000 0060            REGSTACK - 1 = CPCR      % R(A) INTO MAR2
145B  2F30 0000 0000 0060            EINPUT - 1 = CPCR        % (R(A)) INTO B
145C  4809 0C52 0000 00F0            B EQL 0
145D  500B 0000 0000 00FC            IF TRUE THEN STEP ELSE SKIP
145E  103C 0000 0000 0040            BUMP - 1 = MPCR          % ADVANCE THE PAR BY 1 AND CALL OPCODE
145F  5700 0000 0000 0060            RXMFIELD - 1 = CPCR      % ANALYZE "M" FIELD
1460  4809 0C41 0010 00FC            D L = BR2                % ADDRESS OF Y INTO BR2
1461  0000 0000 0000 0030            COMP 8 = SAR
1462  60E0 0000 0000 0060            EMULIN - 1 = CPCR        % (Y) IN B
1463  4809 A000 0000 00F0            A1 R = A1
1464  0000 0000 0000 0020            COMP 16 = SAR
1465  4809 A001 4000 00F0            A1 L = A1
1466  4809 AC5C 4000 00F0            A1 OR B = A1             % CREATE NEW PAR
1467  66E0 0000 0000 0040            OPCODE - 1 = MPCR
                                                              %
                                                              %
                           OPCODE46:                          % JUMP POSITIVE
1468  5F90 0000 0000 0080            XFCODE - 1 = CPCR        % GET "F" CODE IN A2
1469  4809 C640 0040 00FC            A2 + AMPCR = AMPCR
146A  1E10 0000 0000 00C0            OP46F - 1 = AMPCR
146B  4809 0000 0000 00F0            STEP
146C  4824 0000 0000 00F0            EXEC
                                                              %
                                                              %
146D  1E20 0000 0000 0040  OP46F:    OP460 - 1 = MPCR
146E  1E30 0000 0000 0040            OP461 - 1 = MPCR
146F  1E40 0000 0000 0040            OP462 - 1 = MPCR
1470  1E50 0000 0000 0040            OP463 - 1 = MPCR
                                                              %
                                                              %
                           OP460:                             % RR TYPE JUMP POSITIVE
                                                              % IF (R(A)) >= 0, (R(M)) INTO P
1471  2280 0000 0000 0060            CONTENTSRA - 1 = CPCR    % (R(A)) INTO B
1472  4809 0C41 0800 00F0            B L = B                  % SHIFT (R(A)) TO MS WORD
1473  0000 0000 0000 0020            COMP 16 = SAR
1474  4809 0C40 0000 00F0            B                        % PUT B IN THE ADDER
1475  480E 0000 0000 00F0            IF MST THEN STEP ELSE SKIP  % TEST (R(A)) >= 0
1476  66E0 0000 0000 0040            OPCODE - 1 = MPCR
1477  2380 0000 0000 0060            CONTENTSRM - 1= CPCR     % (R(M)) INTO P
1478  4809 A000 0000 00FC            A1 R = A1                % CLEAR THE PAR FIELD
1479  0000 0000 0000 0020            COMP 16 = SAR
147A  4809 A001 4000 00F0            A1 L = A1
147B  4009 AC5C 4000 00F0            A1 OR B = A1             % SET UP NEW PAR
147C  66E0 0000 0000 0040            OPCODE - 1 = MPCR
                                                              %
                                                              %
                           OP461:                             % RI TYPE 1 LOCAL JUMP >=
147D  2260 0000 0000 0060            CHECKCC - 1 = CPCR       % RETURN CC IN LS BITS OF B
147E  4809 2C52 0000 00F0            LIT EQL B                % TEST FOR <
147F  0030 0000 0000 00E0            3 = LIT
1480  680B 0000 0000 00FC            IF TRUE THEN STEP ELSE SKIP
1481  66E0 0000 0000 0040            OPCODE - 1 = MPCR
1482  559C 0000 0000 0040            RI1 - 1 = MPCR           % (P) + D = P
                                                              %
                                                              %
                           OP462:                             % RK TYPE JUMP POSITIVE
                                                              % IF (R(A)) >= 0, Y INTO P
1483  2280 0000 0000 0060            CONTENTSRA - 1 = CPCR    % (R(A)) INTO B
1484  4809 0C41 0800 00F0            B L = B                  % SHIFT (R(A)) INTO MS WORD OF B
```

```
1485  0000 0000 0000 0020            COMP 16 = SAR
1486  4809 0C40 C000 00F0            B                       % PUT B IN THE ADDER
1487  480B 0C00 0000 00F0            IF MST THEN STEP ELSE SKIP
1488  1D30 0000 0000 0040            BUMP - 1 = MPCR         % ADVANCE THE PAR BY 1 AND CALL OPCODE
1489  4809 E156 1000 00F0            A3 AND LIT = A3         % "M" FIELD IN A3
148A  00FC 0000 0000 00E0            15 = LIT
148B  4809 E012 0000 C0F0            A3 EOL 0
148C  6C19 0000 0B00 00F0            IF TRUE THEN 0 = B; SKIP
148D  238C 0000 C000 006C            CONTENTSRM - 1 = CPCR   % (R(M)) INTO 9
148E  4809 0C40 1000 00F0            B = A3
148F  633C 0000 0000 C06C            IFETCH - 1 = CPCR       % Y INTO B
1490  48C9 EC40 CB00 00F0            A3 + B = B              % PUT PAR IN LS WORD OF B
1491  4809 AC00 C000 00F0            A1 R = A1
1492  0000 0000 0000 C020            COMP 16 = SAR
1493  48C9 A0C1 4000 00FC            A1 L = A1               % CLEAR PAR FROM PSW
1494  4809 AC5C 4000 C0FC            A1 OR B = A1
1495  66EC 0000 0000 C040            OPCODE - 1 = MPCR
                                                             %
                                                             %
                           OP463:                            % RX JUMP POSITIVE
                                                             % IF (R(A)) >= 0, (Y) INTO P
1496  4809 0C40 8B00 C0F0            B R = B                 % "A" INTO LS BITS
1497  80FC 0000 C000 C080            4 = SAR; 15 = LIT
1498  48C9 2C56 0B00 C0F0            LIT AND B = P           % ISOLATE "A" INTO B
1499  51CC C000 0000 C06C            REGSTACK - 1 = CPCR     % R(A) INTO MAR2
149A  2F3C C000 0000 C060            EINPUT - 1 = CPCR       % (R(A)) INTO E
149B  4809 0C41 0B00 C0FC            B L = B                 % SHIFT (R(A)) INTO MS WORD OF B
149C  0000 C000 0000 0020            COMP 16 = SAR
149D  4809 CC40 0000 00F0            B                       % PUT B IN THE ADDER
149E  48CB C000 0000 C0F0            IF MST THEN STEP ELSE SKIP
149F  1D30 0000 0000 C04C            BUMP - 1 = MPCR         % ADVANCE THE PAR BY 1 AND CALL OPCODE
14A0  4809 E000 0B00 C0F0            A3 = B
14A1  5700 0000 000C 0060            RXMFIELD - 1 = CPCR
14A2  48C9 0C41 0010 00F0            B L = BR2               % PUT Y INTO BR2
14A3  0C00 C0C0 0000 C030            COMP 8 = SAR
14A4  60EC 0000 0000 0060            EMULIN - 1 = CPCR       % PUT (Y) INTO B
14A5  4809 A000 C000 C0FC            A1 R = A1               % CLEAR OLD PAR
14A6  0000 0000 0C00 C02C            COMP 16 = SAR
14A7  48C9 A0C1 4C00 C0FC            A1 L = A1
14A8  4809 AC5C 4000 C0FC            A1 OR B = A1            % CREATE NEW PAR
14A9  66EC 0000 0000 0040            OPCODE - 1 = MPCR
                                                             %
                                                             %
                           OPCODE47:                         % JUMP NEGATIVE INSTRUCTION
14AA  5F9C 0000 C000 C06C            XFCODE - 1 = CPCR       % RETURNS "F" FIELD IN LSB OF A2
14AB  4809 C640 0040 00F0            A2 + AMPCR = AMPCR
14AC  1E6C C000 C000 C0C0            OP47F - 1 = AMPCR
14AD  4809 0000 0C0C C0F0            STEP
14AE  4824 0C00 0000 00FC            EXEC                    % JUMP TO DESIRED FORMAT TYPE
                                                             %
                                                             %
14AF  1E70 0000 0000 C04C  OP47F:    OP470 - 1 = MPCR
14B0  1E8C 0000 0000 0040            OP471 - 1 = MPCR
14B1  1E9C C000 0000 0040            OP472 - 1 = MPCR
14B2  1EA0 C000 0000 0040            OP473 - 1 = MPCR
                                                             %
                                                             %
                           OP470:                            % RR FORMAT JUMP REGISTER NEGATIVE
                                                             % IF (R(A)) < 0, (R(M)) INTO P
14B3  22BC C000 0000 0060            CONTENTSRA - 1 = CPCR   % (R(A)) INTO B
```

```
14B4  4809 0C41 0B00 C0F0          B L = B                    % SHIFT (R(A)) INTO UHW OF B              06778000 D
14B5  0000 0003 0000 C020          COMP 16 = SAR                                                        06779000 D
14B6  4809 0C40 0000 00F0          B                          % PUT B IN THE ADDER, TEST (R(A)) < 0     06780000 D
14B7  4819 C003 C02C 00FC          IF MST THEN SKIP                                                     06781000 D
14B8  66EC 0C03 CC0C C040          OPCODE - 1 = MPCR                                                    06782000 D
14B9  2380 0000 0000 C06C          CONTENTSRM - 1 = CPCR % (R(M)) INTO D                                06783000 D
14BA  4809 ACC0 CC0C 00F0          A1 R = A1                  % CLEAR LOWER 16 BITS OF A1               06784000 D
14BB  000C 00C0 0C0C 0020          COMP 16 = SAR                                                        06785000 D
14BC  4809 ACC1 4C00 00F0          A1 L = A1                                                            06786000 D
14BD  4809 AC5C 4000 C0F0          A1 OR B = A1               % MODIFY PAR TO JUMP                      06787000 D
14BE  56EC 0000 0000 CC40          OPCODE - 1 = MPCR                                                    06788000 D
                                                              %                                         06789000 D
                                                              %                                         06790000 D
                       OP471:                                 % RI TYPE 1 LOCAL JUMP LESS INSTRUCTION   06791000 D
                                                              % IF (CC) = 11, (P) + D = P               06792000 D
14BF  2809 0000 0C0C C0F0          IF LC1                                                               06793000 D
14C0  226C C0C0 0C00 0C6C          CHECKCC - 1 = CPCR         % PUT THE CC BITS INTO B                  06794000 D
14C1  4809 2C52 000C C0F0          LIT EOL B                  % CHECK CC FOR 11                         06795000 D
14C2  003C C0C3 000C 00E0          3 = LIT                                                              06796000 D
14C3  6CCB C0C0 C000 C0FC          IF FALSE THEN STEP ELSE SKIP                                         06797000 D
14C4  66EC 00C0 C000 0040          OPCODE - 1 = MPCR                                                    06798000 D
14C5  5590 0000 0000 0C4C          R11 - 1 = MPCR             % (P) + D = P                             06799000 D
                                                              %                                         06800000 D
                                                              %                                         06801000 D
                       OP472:                                 % RK TYPE JUMP NEGATIVE                   06802000 D
                                                              % IF (R(A)) < 0, (Y) = P                  06803000 D
14C6  22BC 0C03 000C 0060          CONTENTSRA - 1 = CPCR  % (R(A)) INTO B                               06804000 D
14C7  4809 0C41 CB00 C0F0          B L = B                    % SHIFT (R(A)) INTO UHW OF B              06805000 D
14C8  00C0 00C0 000C 0020          COMP 16 = SAR                                                        06806000 D
14C9  4809 0C40 00CC CCFC          B                          % CHECK IF (R(A)) < 0                     06807000 D
14CA  4819 00C0 0000 C0F0          IF MST THEN SKIP                                                     06808000 D
14CB  1D3C C0C0 0C00 C04C          BUMP - 1 = MPCR            % ADVANCE THE FAR BY 1 AND CALL OPCODE    06809000 D
14CC  2380 C0C3 000C C060          CONTENTSRM - 1 = CPCR % (R(M)) INTO E                                06810000 D
14CD  4809 0C40 1000 00F0          B = A3                                                               06811000 D
14CE  633C C0C3 0000 006C          IFETCH - 1 = CPCR          % PUT Y INTO B                            06812000 D
14CF  4009 EC40 0B0C 00F0          A3 + B = B                 % PUT PAR VALUE IN LS WORD OF B           06813000 D
14D0  4809 ACC0 C000 00FC          A1 R = A1                  % CLEAR OLD PAR                           06814000 D
14D1  0C0C 0000 000C 002C          COMP 16 = SAR                                                        06815000 D
14D2  4809 A001 4000 00FC          A1 L = A1                                                            06816000 D
14D3  4809 AC5C 4C00 C0FC          A1 OR B = A1               % CONSTRUCT NEW PAR                       06817000 D
14D4  56EC C0C0 000C 0040          OPCODE - 1 = MPCR                                                    06818000 D
                                                              %                                         06819000 D
                                                              %                                         06820000 D
                       OP473:                                 % RX TYPE JUMP INSTRUCTION                06821000 D
                                                              % IF (R(A)) < 0, (Y) = P                  06822000 D
14D5  4809 0C40 8B00 00FC          E R = B                    % SHIFT "A" INTO LS BITS OF B             06823000 D
14D6  90F0 C0C0 0C0C 0080          4 = SAR; 15 = LIT                                                    06824000 D
14D7  4809 2C56 0B0C C0F0          LIT AND B = B              % ISOLATE "A" INTO B                      06825000 D
14D8  51C0 00C0 C000 C060          REGSTACK - 1 = CFCR        % R(A) INTO MAR2                          06826000 D
14D9  2F30 0C03 0000 006C          EINPUT - 1 = CPCR          % (R(A)) INTO E                           06827000 D
14DA  4809 0C41 0B00 00F0          B L = B                    % (R(A)) SHIFTED INTO UHW OF B            06828000 D
14DB  0000 0000 0C00 C02C          COMP 16 = SAR                                                        06829000 D
14DC  4809 0C40 0000 C0FC          B                          % CHECK IF (R(A)) < 0                     06830000 D
14DD  4819 0000 0C00 00F0          IF MST THEN SKIP                                                     06831000 D
14DE  1D3C 0CC0 CC00 C04C          BUMP - 1 = MPCR            % ADVANCE THE FAR BY 1 AND CALL OPCODE    06832000 D
14DF  4809 E0C0 0B00 C0FC          A3 = B                     % RESTORE INSTRUCTION IN B                06833000 D
14E0  570C 00C3 000C C060          RXMFIELD - 1 = CFCR        % ANALYZE "M" FIELD                       06834000 D
14E1  4809 0C41 CC10 C0F0          E L = RR2                  % PUT Y INTO RR2                          06835000 D
14E2  000C 00C3 0000 0C30          COMP 8 = SAR                                                         06836000 D
14E3  5GE0 C0C0 0C00 CC60          EMULIN - 1 = CPCR          % PUT (Y) INTO B                          06837000 D
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14E4  4809 A000 C000 C0F0            A1 R = A1                   % CLEAR THE OLD PAR                    06838000 D
14E5  000C 0000 0000 0020            COMP 16 = SAR                                                      06839000 D
14E6  4809 A001 4000 00F0            A1 L = A1                                                          06840000 D
14E7  4809 AC5C 4000 00F0            A1 OR B = A1                % PUT (Y) INTO THE PAR                 06841000 D
14E8  66EC 0000 0000 0C40            OPCODE - 1 = MPCR                                                  06842000 D
                                                                 %                                      06843000 D
                                                                 %                                      06844000 D
                          OPCODE50:                              % NOT IMPLEMENTED                      06845000 D
14E9  4E5C 0000 0000 0040            NOTIMP - 1 = MPCR                                                  06846000 D
                                                                 %                                      06847000 D
                          OPCODE51:                              % NOT IMPLEMENTED                      06848000 D
14EA  4E5C 0000 0000 0040            NOTIMP - 1 = MPCR                                                  06849000 D
                                                                 %                                      06850000 D
                          OPCODE52:                              % NOT IMPLEMENTED                      06851000 D
14EB  4E50 0000 0000 004C            NOTIMP - 1 = MPCR                                                  06852000 D
                                                                 %                                      06853000 D
                          OPCODE53:                              % NOTIMPLEMENTED                       06854000 D
14EC  4E50 0000 0000 0040            NOTIMP - 1 = MPCR                                                  06855000 D
                                                                 %                                      06856000 D
                                                                 %                                      06857000 D
                          OPCODE54:                              % LOAD ADDRESS REGISTER(S)             06858000 D
14ED  5F90 0000 0000 C06C            XFCODE - 1 = CPCR                                                  06859000 D
14EE  4809 C640 CC40 0CF0            A2 + AMPCR = AMPCR                                                 06860000 D
14EF  1EBC 0000 C000 00C0            OP54F - 1 = AMPCR                                                  06861000 D
14F0  4809 0000 0000 C0FC            STEP                                                               06862000 D
14F1  4824 0000 0000 00F0            EXEC                                                               06863000 D
                                                                 %                                      06864000 D
14F2  1ECC 0000 0C00 0040 OP54F:     OP540 - 1 = MPCR                                                   06865000 D
14F3  1ED0 C000 0000 0040            OP541 - 1 = MPCR                                                   06866000 D
14F4  300C 0C00 0000 0040            FAULT - 1 = MPCR                                                   06867000 D
14F5  1EE0 0000 0000 0040            OP543 - 1 = MPCR                                                   06868000 D
                                                                 %                                      06869000 D
                          OP540:                                 % LARR: LOAD ADDRESS REGS: TYPE RR     06870000 D
14F6  4809 E155 0B00 00F0            A3 AND LIT = B                                                     06871000 D
14F7  00FC 0000 000C C0E0            15 = LIT                                                           06872000 D
14F8  51CC 0000 0000 006C            REGSTACK - 1 = CPCR                                                06873000 D
14F9  2F30 C000 0000 C060            EINPUT - 1 = CPCR           % B = (R(M))                           06874000 D
14FA  4809 0C40 0030 C0F0            B = MIR                                                            06875000 D
                                                                 %                                      06876000 D
14FB  4809 E000 8B0C 00F0 LAR:       A3 R = D                                                           06877000 D
14FC  30F0 0000 0C00 0080            4 = SAR; 15 = LIT                                                  06878000 D
14FD  4809 2C56 CB00 CCF0            LIT AND B = B               % B = R(A)                             06879000 D
14FE  51C0 0000 0000 0060            REGSTACK - 1 = CPCR                                                06880000 D
14FF  2F3C 0000 000C CC6C            EINPUT - 1 = CPCR           % B = (R(A))                           06881000 D
1500  48C9 2C56 2000 C0F0            LIT AND B = A2              % A2 = (R(A))7-0                       06882000 D
1501  0FFC C0C0 CC0C 00E0            255 = LIT                   % 8 BIT MASK                           06883000 D
1502  4809 C640 001C C0F0            A2 + AMPCR = MAR2           % MAR2 = AR                            06884000 D
1503  3000 C000 0000 00C0            PAGEREG = AMPCR             % ADD EASE ADDR + A2                   06885000 D
1504  4809 0000 0000 C0F0            STEP                        % SEPARATE AMPCR ASSIGNMENTS           06886000 D
1505  2F50 0000 0000 C06C            EOUTPUT - 1 = CPCR                                                 06887000 D
1506  66EC 0000 0C00 C040            OPCODE - 1 = MPCR                                                  06888000 D
                                                                 %                                      06889000 D
                          OP541:                                 % LARI: LOAD ADDRESS REGISTER (INDIRECT) 06890000 D
                                                                 % (Y*) -> AR R                         06891000 D
1507  4809 E156 0B00 C0F0            A3 AND LIT = B                                                     06892000 D
1508  00FC 0000 C000 C0EC            15 = LIT                                                           06893000 D
1509  51C0 0000 C000 0060            REGSTACK - 1 = CPCR                                                06894000 D
150A  2F30 C000 0000 0060            EINPUT - 1 = CPCR           % B = (R(M)) = Y*                      06895000 D
150B  4809 0C41 0010 C0F0            D L = BR2                   % Y* INTO BR2                          06896000 D
150C  0000 C000 0000 C030            COMP 8 = SAR                                                       06897000 D
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150D  50EC 0000 0000 0060          FMULIN - 1 = CPCR       % B = (Y*)                                  06898000 D
150E  4809 0C40 003C 00FC          B = MIR                                                             06899000 D
150F  4FA0 C000 0000 0050          LAR - 1 = MPCR                                                      06900000 D
                                                           %                                           06901000 D
                         OP543:                            % LARM; LOAD ADDRESS REG. MULTIPLE          06902000 D
                                                           %(Y,...Y+U) -> AR R...AR R+U                06903000 D
                                                           % MULTIPLE LOADS OBSERVE PAGE               06904000 D
                                                           % ADDRESSES                                 06905000 D
1510  57C0 0003 0000 006D          RXMFIELD - 1 = CPCR     % B = Y                                     06906000 D
1511  4809 0C40 003C 00F0          B = MIR                                                             06907000 D
1512  4809 E000 8B00 00FD          A3 R = B                                                            06908000 D
1513  80FC 0000 0000 0080          4 = SAR; 15 = LIT                                                   06909000 D
1514  4809 2C56 0B00 00F0          LIT AND B = B           % B = :A: FIELD                             06910000 D
1515  51C0 0000 0000 006C          REGSTACK - 1 = CPCR                                                 06911000 D
1516  2F30 0003 000C 0060          EINPUT - 1 = CPCR       % B = (R(A))                                06912000 D
1517  0FF0 0000 0000 009C          255 = LIT ; 8 = SAR     % A2 = PAGE REG NUM.                        06913000 D
1518  4809 2C56 2000 00F0          LIT AND B = A2                                                      06914000 D
1519  4809 C640 1000 00F0          A2 + AMPCR = A3         % A3 = AR R                                 06915000 D
151A  3C0C 0000 0000 000C          PAGEREG = AMPCR                                                     06916000 D
151B  49C9 0C40 8B00 00F0          B R = B; SET LC1        % B HAS COUNT: LC1 SET FOR R +1 MOVE        06917000 D
151C  4809 0C52 0000 00F0          C EOL B                 % COUNT OF ZERO CAUSES ALL REG TO BE        06918000 D
151D  0FFC C000 000C 00A0          255 = LIT; COMP 16 = SAR                                            06919000 D
151E  6C19 2C01 0B00 00FD          IF TRUE THEN LIT + 1 L = B: SKIP                                    06920000 D
151F  4809 0C47 0B00 00F0          B + 1 L = B                                                         06921000 D
1520  4809 EC5C 1000 00F0          A3 OR B = A3,BM1        % COUNT IN UHW OF A3                        06922000 D
1521  4809 0C41 0020 00F0          B L = BR1               % ORIGIN ADDR IN BR1                        06923000 D
1522  0000 0000 0000 0030          COMP 8 = SAR                                                        06924000 D
1523  4A20 0000 0000 006D          MOVE - 1 = CPCR                                                     06925000 D
1524  66EC 0000 0000 0040          OPCODE - 1 = MPCR                                                   06926000 D
                                                           %                                           06927000 D
                                                           %                                           06928000 D
                         OPCODE55:                         % STORE ADDRESS REGISTER(S)                 06929000 D
1525  5F9C 0000 0000 0060          XFCODE - 1 = CPCR                                                   06930000 D
1526  4809 C640 0040 00FC          A2 + AMPCR = AMPCR                                                  06931000 D
1527  1EFC 0000 0000 000C          OP55F - 1 = AMPCR                                                   06932000 D
1528  4809 0000 0000 00FC          STEP                                                                06933000 D
1529  4824 0000 0000 00FD          EXEC                                                                06934000 D
                                                           %                                           06935000 D
152A  1F0C 0000 0000 004C OP55F:   OP550 - 1 = MPCR                                                    06936000 D
152B  1F10 0000 0000 0040          OP551 - 1 = MPCR                                                    06937000 D
152C  3000 0000 0000 0040          FAULT - 1 = MPCR                                                    06938000 D
152D  1F2C 0000 0000 0040          OP553 - 1 = MPCR                                                    06939000 D
                                                           %                                           06940000 D
                         OP55D:                            % SARR; STORE ADDRESS REGISTER (REGISTER)06941000 D
                                                           % TYPE RR: (AR) A -> RM                     06942000 D
152E  4809 0C40 8B00 00FC          B R = B                                                             06943000 D
152F  80FC 0000 0000 0080          4 = SAR; 15 = LIT                                                   06944000 D
1530  4809 2C56 0B00 00F0          LIT AND B = B                                                       06945000 D
1531  51C0 0000 0000 006D          REGSTACK - 1 = CPCR     % MAR2 = RA                                 06946000 D
1532  2F30 0000 0000 0060          EINPUT - 1 = CPCR       % B = (R(A))                                06947000 D
1533  4809 2C56 2000 00FC          LIT AND B = A2          % A2 = REG NUM.                             06948000 D
1534  0FFC 0000 0000 00E0          255 = LIT                                                           06949000 D
1535  4809 C643 001C 00F0          A2 + AMPCR = MAR2                                                   06950000 D
1536  3000 0000 0000 00C0          PAGEREG = AMPCR         % PAGEREG BASE + REG #                      06951000 D
1537  4809 0003 0000 00FC          STEP                    % SEPARATE AMPCR ASSIGNMENTS                06952000 D
1538  2F30 0000 0000 006C          EINPUT - 1 = CPCR       % B = (AR)                                  06953000 D
1539  4809 0C40 003C 00F0          B = MIR                                                             06954000 D
153A  4809 E156 0B00 00F0          A3 AND LIT = B          % B = :M: FIFLO                             06955000 D
153B  0CFC 0000 0000 00E0          15 = LIT                                                            06956000 D
153C  51C0 0000 0000 006C          REGSTACK - 1 = CPCR     % MAR2 = RM                                 06957000 D
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153D  2F5C 0000 0000 0060          EOUTPUT - 1 = CPCR     % (AR) -> RM                                  06958000 D
153E  66E0 0000 0000 0040          OPCODE - 1 = MPCR                                                   06959000 D
                                                          %                                             06960000 D
                         OP551:                           % SARI; STORE ADDRESS REGISTER                06961000 D
                                                          % TYPE RI; (AR) A -> Y*                       06962000 D
153F  4809 0C40 8B00 C0F0          B R = B                                                             06963000 D
1540  80F0 0000 0000 0080          4 = SAR; 15 = LIT                                                   06964000 D
1541  4809 2C56 0B00 C0F0          LIT AND B = B          % B = :A: FIELD                               06965000 D
1542  51C0 0000 0000 0060          REGSTACK - 1 = CPCR    % MAR2 = R#                                   06966000 D
1543  2F30 0000 0000 0060          EINPUT - 1 = CPCR      % B = (R(A))                                  06967000 D
1544  4809 2C56 2000 C0F0          LIT AND B = A2         % A2 = REG #                                  06968000 D
1545  0FFC 0000 0000 00E0          255 = LIT                                                           06969000 D
1546  4809 C640 001C C0F0          A2 + AMPCR = MAR2                                                   06970000 D
1547  300C 0000 0000 00CC          PAGEREG = AMPCR        % PAGEREG BASE + REG #                        06971000 D
1548  4809 0000 0000 00F0          STEP                   % SEPARATE AMPCR ASSIGNMENTS                  06972000 D
1549  2F30 0000 0000 0060          EINPUT - 1 = CPCR      % B = (AR)                                    06973000 D
154A  4809 0C40 0030 00F0          B = MIR                                                             06974000 D
154B  4809 E156 0B00 00F0          A3 AND LIT = B         % B = :M: FIELD                               06975000 D
154C  00FC 0000 0000 C0E0          15 = LIT                                                            06976000 D
154D  51C0 0000 0000 0060          REGSTACK - 1 = CPCR                                                 06977000 D
154E  2F30 0000 0000 0060          EINPUT - 1 = CPCR      % B = (R(M)) = Y*                             06978000 D
154F  48C9 0C41 001C 00F0          B L = BR2              % Y* INTO BR2                                 06979000 D
1550  0000 0000 0000 0030          COMP 8 = SAR                                                        06980000 D
1551  51EC 0000 0000 0060          EMULOUT - 1 = CPCR     % (AR) -> Y*                                  06981000 D
1552  56E0 C000 0000 0040          OPCODE - 1 = MPCR                                                   06982000 D
                                                          %                                             06983000 D
                         OP553:                           % STORE ADDRESS REGISTER MULTIPLE             06984000 D
                                                          % SARM; TYPE RX (AR R,...AR R+U) ->           06985000 D
                                                          % Y,...Y+U                                    06986000 D
                                                          % MULTIPLE STORES DO OBSERVE PAGE             06987000 D
                                                          % ADDRESSES                                   06988000 D
1553  5700 0000 0000 0060          RXMFIELD - 1 = CPCR                                                 06989000 D
1554  4809 0C40 0030 C0FC          B = MIR                % MIR = Y                                     06990000 D
1555  4809 E0C0 8B00 C0F0          A3 R = B                                                            06991000 D
1556  80F0 0000 0000 C080          4 = SAR; 15 = LIT                                                   06992000 D
1557  4809 2C56 0B00 00F0          LIT AND B = B          % B = :A: FIELD                               06993000 D
1558  51C0 0000 0000 0060          REGSTACK - 1 = CPCR                                                 06994000 D
1559  2F30 0000 0000 0060          EINPUT - 1 = CPCR      % B = (R(A))                                  06995000 D
155A  4809 2C56 2000 C0F0          LIT AND B = A2         % A2 HAS PAGE REG #                           06996000 D
155B  0FF0 0000 0000 0090          255 = LIT; 8 = SAR                                                  06997000 D
155C  4809 C640 1000 C0FC          A2 + AMPCR = A3        % B = AR R                                    06998000 D
155D  3000 0000 0000 00CC          PAGEREG = AMPCR                                                     06999000 D
155E  4809 0C40 8B00 00F0          E R = B                % SHIFT COUNT INTO LS BITS OF B               07000000 D
155F  4809 0C52 0C00 00F0          0 EOL B                % A COUNT OF ZERO MEANS ALL REG STORED        07001000 D
1560  0FF0 0000 0000 C0AC          255 = LIT; COMP 16 = SAR                                            07002000 D
1561  6C19 20C1 9B00 00F0          IF TRUE THEN LIT + 1 L = B; SKIP                                    07003000 D
1562  4809 CC47 0B00 00F0          B + 1 L= B             % COUNT IN B                                  07004000 D
1563  4809 E001 0020 00F0          A3 L = BR1             % ORIGIN ADDR IN BR1                          07005000 D
1564  0000 0000 0000 C030          COMP 8 = SAR                                                        07006000 D
1565  4809 0C40 1D00 00F0          B = A3,BMI             % COUNT IN UHW OF A3                          07007000 D
1566  4809 EC5C 1000 00F0          A3 OR B = A3           % DESTINATION ADDR IN LHW OF A3               07008000 D
1567  4A2C 0000 C000 0060          MOVE - 1 = CPCR                                                     07009000 D
1568  66E0 C000 0000 C040          OPCODE - 1 = MPCR                                                   07010000 D
                                                          %                                             07011000 D
                                                          %                                             07012000 D
                         OPCODE56:                        % NOT IMPLEMENTED                             07013000 D
1569  4E5C 0000 0000 0040          NOTIMP - 1 = MPCR                                                   07014000 D
                                                          %                                             07015000 D
                         OPCODE57:                        % NOT IMPLEMENTED                             07016000 D
156A  4E50 0000 C000 004C          NOTIMP - 1 = MPCR                                                   07017000 D
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                                                        *
156B  5F90 0000 0000 0060   OPCODE60:  XFCODE - 1 = CPCR
156C  4809 C640 0030 00F0              A2 + AMPCR = AMPCR
156D  1F30 0000 0000 00C0              OP60F - 1 = AMPCR
156E  4809 0000 0030 C0F0              STEP
156F  4824 0000 0000 C0F0              EXEC
                                                        *
1570  1F40 0000 C000 0040   OP60F:     OP600 - 1 = MPCR
1571  1F50 0000 0000 C040              OP601 - 1 = MPCR
1572  1F60 0000 C0C0 C040              OP602 - 1 = MPCR
1573  1F70 0000 0000 C040              OP603 - 1 = MPCR
                                                        *
                                                        *
                            OP600:                      * RL TYPE LOGIC RIGHT SINGLE SHIFT
                                                        * SHIFT (R(A)) RIGHT M (0-3), SET CC,
1574  2280 0000 C000 0060              CONTENTSRA - 1 = CPCR * AND ZEROFILL
1575  4809 E156 1000 00F0              A3 AND LIT = A3  * "M" INTO A3
1576  00FC C000 0030 00E0              15 = LIT
1577  4809 E000 0000 80F0              A3 = SAR
1578  4809 CC40 8030 00F0              B R = MIR, B
1579  2000 0000 C000 0060              SETCCA - 1 = CPCR  * SET THE CONDITION BITS
157A  2F5C 0000 0000 0060              EOUTPUT - 1 = CPCR
157B  66EC 0000 000C 0040              OPCODE - 1 = MPCR
                                                        *
                                                        *
                            OP601:                      * RL TYPE ALG RIGHT SINGLE SHIFT
                                                        * (R(A)) RIGHT M (0-3), SIGN FILL, SET CC
157C  2809 0000 0000 C0F0              IF LC1
157D  228C C0C0 0000 0060              CONTENTSRA - 1 = CPCR, * (R(A)) INTO B
157E  4809 0C00 2000 00F0              C = A2
157F  4809 0C41 0E30 C0F0              B L = B
1580  000C 0000 C000 C020              COMP 16 = SAR
1581  4809 0C40 0000 C0FC              B
1582  4C09 C018 2030 00F0              IF MST THEN B111 = A2
1583  4809 E156 1030 00F0              A3 AND LIT = A3
1584  00FC C0C0 000C 00A0              15 = LIT; COMP 16 = SAR
1585  4809 CCC1 2000 C0F0              A2 L = A2         * A2 = 000C/C0C0 OR 1111/C00C
1586  4809 CC40 8B00 00FC              B R = B
1587  4809 CC5C 0B0C C0F0              A2 OR B = B       * B = 1111/(R(A)) OR 0000/(R(A))
1588  4809 E0C0 0000 80FC              A3 = SAR
1589  4809 0C40 8B00 00F0              B R = B           * PERFORM ALG RIGHT SINGLE SHIFT
158A  4809 CC41 0B0C C0F0              B L = B           * CLEAR UHW OF B
158B  0000 0000 C000 C020              COMP 16 = SAR
158C  4809 CC40 8B3C 00F0              B R = D, MIR
158D  2F5C 0000 C000 0060              EOUTPUT - 1 = CPCR
158E  2000 C0C0 0000 C060              SETCCA - 1 = CPCR  * SET THE CONDITION BITS
158F  66EC 0000 0C00 C040              OPCODE - 1 = MPCR
                                                        *
                                                        *
                            OP602:                      * RL TYPE LOGICAL RIGHT DOUBLE SHIFT
                                                        * (R(A),R(A+1)) M (0-3) PLACES, ZERO FILL
                                                        * AND SET CC
1590  4809 2C56 2000 C0F0              LIT AND B = A2    * ISOLATE "M"
1591  90F0 0CC0 003C 008C              15 = LIT; 4 = SAR
1592  4809 0C40 8B30 C0F0              B R = B
1593  4809 2C56 0B0C 00FC              LIT AND B = B     * OBTAIN "A" FIELD
1594  51CC 0000 0000 C060              REGSTACK - 1 = CPCR
1595  4809 0F41 0020 00F0              BMAR L = BR1
1596  0000 C0C0 CC0C C030              COMP 8 = SAR
1597  2F30 0000 000C 0060              EINPUT - 1 = CPCR  * (R(A)) INTO B
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1598  4809 0C41 1000 00F0          B L = A3                                                 07078000 D
1599  001C 0000 0000 00A0          16 = SAR ; 1 = LIT                                       07079000 D
159A  4809 2F5C 001C 00FC          LIT OR BMAR = MAR2      % R(A+1)                         07080000 D
159B  2F30 0000 0C00 0060          EINPUT - 1 = CPCR       % (R(A+1)) INTO B                07081000 D
159C  4809 EC5C 100C 00F0          A3 OR B = A3            % A3 = (R(A))/(R(A+1))           07082000 D
159D  4809 CC00 C00C 80FC          A2 = SAR                                                 07083000 D
159E  49C9 E000 9800 00FC          A3 R = A3,B; SET LC1    % PERFORM DOUBLE SHIFT           07084000 D
159F  2000 0000 C00C 0060          SETCCA - 1 = CPCR       % SET THE CONDITION BITS         07085000 D
15A0  4809 E001 0B00 00F0          A3 L = B                                                 07086000 D
15A1  0000 0000 C000 C020          COMP 16 = SAR                                            07087000 D
15A2  4809 0C40 903C C0F0          B R = MIR               % NEW (R(A+1))                   07088000 D
15A3  2F50 0000 0000 0060          EOUTPUT - 1 = CPCR      % WRITE NEW R(A+1)               07089000 D
15A4  4809 0000 C000 20F0          ASR                     % REFERENCE BR1                  07090000 D
15A5  4809 0F43 801C 00FC          BMAR R = MAR2           % R(A)                           07091000 D
15A6  0000 000D 0000 C010          8 = SAR                                                  07092000 D
15A7  4809 E003 8030 00F0          A3 R = MIR              % (R(A))                         07093000 D
15A8  000C C003 000C C02C          16 = SAR                                                 07094000 D
15A9  2F5C 0000 000C 0C60          EOUTPUT - 1 = CPCR                                       07095000 D
15AA  56E0 0003 0C0C 0040          OPCODE - 1 = MPCR                                        07096000 D
                                                           %                                07097000 D
                                                           %                                07098000 D
                            0F603:                         % RL TYPE ALG RIGHT DOUBLE SHIFT  07099000 D
                                                           % RIGHT SHIFT (R(A),R(A+1)), M (0-3)  07100000 D
                                                           % SIGN FILL AND SET CC           07101000 D
15AB  4809 2C56 2030 C0FC          LIT AND B = A2          % ISOLATE "M" FIELD              07102000 D
15AC  00F0 C000 0000 C0E0          15 = LIT                                                 07103000 D
15AD  28C9 CC40 8B00 C0FC          B R = B; IF LC1                                          07104000 D
15AE  80FC 000D C00C C080          4 = SAR; 15 = LIT                                        07105000 D
15AF  4809 2C56 0B00 00F0          LIT AND B = 6                                            07106000 D
15B0  51C0 0000 0000 0060          REGSTACK - 1 = CPCR     % R(A) INTO MAR2                 07107000 D
15B1  4809 0F41 0020 00F0          BMAR L = BR1            % TEMP STORAGE                   07108000 D
15B2  0000 C003 0000 0030          COMP 8 = SAR                                             07109000 D
15B3  2F3C 0003 0030 0060          EINPUT - 1 = CPCR       % (R(A)) INTO B                  07110000 D
15B4  4809 0C41 0B00 C0F0          B L = B                                                  07111000 D
15B5  000C 0000 0000 0C2C          COMP 16 = SAR                                            07112000 D
15B6  4809 0C40 0000 C0F0          B                       % PUT B IN THE ADDER             07113000 D
15B7  4BC9 C000 0000 C0F0          IF MST THEN SET LC1     % NEG SIGN FLAG                  07114000 D
15B8  0C10 0000 000C C0A0          COMP 16 = SAR ; 1 = LIT                                  07115000 D
15B9  4809 EC5C 1C0C C0FC          A3 OR B = A3            % A3 = (R(A))/INSTRUCTION        07116000 D
15BA  4809 2F5C 001C C0FC          LIT OR BMAR = MAR2      % R(A+1)                         07117000 D
15BB  2F3C 00C3 000C C060          EINPUT - 1 = CPCR       % (R(A+1)) INTO B                07118000 D
15BC  4809 EC0D 9000 C0F0          A3 R = A3               % CLEAR LHW OF A3                07119000 D
15BD  0000 000D 0000 002C          16 = SAR                                                 07120000 D
15BE  4809 E001 1000 00FC          A3 L = A3                                                07121000 D
15BF  4809 EC5C 1030 C0F0          A3 OR B = A3            % A3 = (R(A))/(R(A+1))           07122000 D
15C0  4809 CC00 C000 80F0          A2 = SAR                                                 07123000 D
15C1  4809 E003 9000 00FC          A3 R = A3               % PERFORM SHIFT                  07124000 D
15C2  4809 0000 0B00 00F0          0 = B                                                    07125000 D
15C3  2C09 0013 0B90 C0F0          IF LC1 THEN B111 = B                                     07126000 D
15C4  4809 0C41 CB00 00F0          B L = B                 % B = 1111/0000 OR B = 0000/0000  07127000 D
15C5  49C9 EC5C 1E00 C0F0          A3 OR B = A3,B; SET LC1                                  07128000 D
15C6  200C 0C0D 0000 C060          SETCCA - 1 = CPCR       % SET THE CONDITION BITS         07129000 D
15C7  4809 EC01 2030 C0FC          A3 L = A2                                                07130000 D
15C8  000C 00C0 0000 C02C          COMP 16 = SAR                                            07131000 D
15C9  4809 C000 8030 CCFC          A2 R = MIR              % (R(A+1)) SHIFTED INTO MIR      07132000 D
15CA  2F50 0C00 0030 C060          EOUTFUT - 1 = CPCR                                       07133000 D
15CB  4809 C000 0C0C 2CF0          ASR                     % REFERKNCE BR1                  07134000 D
15CC  4809 CF43 8C1C 00F0          BMAR R = MAR2           % R(A)                           07135000 D
15CD  000C 0000 C00C 001C          8 = SAR                                                  07136000 D
15CE  4809 E000 8030 00F0          A3 R = MIR                                               07137000 D
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15CF  900C 00C0 0000 0020                16 = SAR                                         07138000 0
15D0  2F5C 0000 0000 C060                EOUTPUT - 1 = CPCR       % WRITE NEW (R(A))      07139000 0
15D1  66EC 0000 0000 C040                OPCODE - 1 = MPCR                                07140000 0
                                                                  %                       07141000 0
                                                                  %                       07142000 0
15D2  5F9C 0000 0000 006C   OPCODE61:    XFCODE - 1 = CPCR        % "F" INTO A2           07143000 0
15D3  4809 C640 0030 00F0                A2 + AMPCR = AMPCR                               07144000 0
15D4  1F80 0000 0000 C0C0                OP61F - 1 = AMPCR                                07145000 0
15D5  4809 CCC0 C030 C0FC                STEP                                             07146000 0
15D6  4824 0000 0000 C0F0                EXEC                                             07147000 0
                                                                  %                       07148000 0
15D7  1F90 C000 000C 0040   OP61F:       OP610 - 1 = MPCR                                 07149000 0
15D8  1FAC 0000 000C C04C                OP611 - 1 = MPCR                                 07150000 0
15D9  1FBC 0CC0 0000 C040                OP612 - 1 = MPCR                                 07151000 0
15DA  1FCC 0C00 0000 0040                OP613 - 1 = MPCR                                 07152000 0
                                                                  %                       07153000 0
                                                                  %                       07154000 0
                            OP610:                                % RL TYPE ALG LEFT SINGLE SHIFT            07155000 0
                                                                  % (R(A)) M (0-3) PLACES, ZERO FILL         07156000 0
                                                                  % SET CC AND SET OVERFLOW BIT              07157000 0
15DB  4809 2C56 200C C0F0                LIT AND B = A2           % "M" FIELD INTO A2     07158000 0
15DC  8CF0 C0C0 C000 C080                15 = LIT; 4 = SAR                                07159000 0
15DD  4809 CC40 8000 0CF0                B R = B                                          07160000 0
15DE  4809 2C56 0B00 C0F0                LIT AND B = B            % ISOLATE "A"           07161000 0
15DF  51CC 0CC0 000C C060                REGSTACK - 1 = CPCR                              07162000 0
15E0  2F3C 0000 0000 0060                EINPUT - 1 = CPCR        % (R(A)) INTO B         07163000 0
15E1  4809 CC02 2000 C0F0                NOT A2 = A2                                      07164000 0
15E2  4809 C0C0 0000 80F0                A2 + 1 = SAR                                     07165000 0
15E3  4809 0C41 0B0C 00F0                B L = B                  % PERFORM LEFT SHIFT    07166000 0
15E4  4809 CC40 A00C CCF0                B R = A2                                         07167000 0
15E5  000C 0000 C000 C020                16 = SAR                                         07168000 0
15E6  4809 C002 0030 C0F0                NOT A2                                           07169000 0
15E7  63C9 0000 000C C0F0                IF NOT ABT THEN SET LC1                          07170000 0
15E8  5020 00C0 C000 0060                OVBIT - 1 = CPCR         % SET THE OVERFLOW BIT  07171000 0
15E9  4809 0C41 0B0C 00F0                B L = B                                          07172000 0
15EA  0000 0C00 C00C C020                COMP 16 = SAR                                    07173000 0
15EB  4809 0C40 8B3C 00F0                B R = MIR, B             % LEFT SHIFTED (R(A))   07174000 0
15EC  2F5C 0C00 0C0C 0060                EOUTPUT - 1 = CPCR       % WRITE NEW (R(A))      07175000 0
15ED  200C 0000 000C C060                SETCCA - 1 = CPCR        % SET THE CONDITION BITS               07176000 0
15EE  66E0 00C0 0C00 C040                OPCODE - 1 = MPCR                                07177000 0
                                                                  %                       07178000 0
                                                                  %                       07179000 0
                            OP611:                                % TYPE RL CIRCULAR LEFT SHIFT          07180000 0
                                                                  % (R(A)) SHIFTED M (0-3) PLACES, SET CC 07181000 0
15EF  4809 2C56 203C 00FC                LIT AND B = A2           % "M" INTO A2           07182000 0
15F0  8CF0 CC0C 000C 008C                15 = LIT; 4 = SAR                                07183000 0
15F1  4809 0C40 8B00 00F0                B R = B                                          07184000 0
15F2  48C9 2C56 CB00 C0FC                LIT AND B = B            % ISOLATE "A" FIELD     07185000 0
15F3  51C0 00C0 000C 0060                REGSTACK - 1 = CPCR                              07186000 0
15F4  2F3C 0CC0 0030 C060                EINPUT - 1 = CPCR        % (R(A)) INTO B         07187000 0
15F5  4809 0C40 1030 00FC                B = A3                                           07188000 0
15F6  4809 E0C1 100C CCF0                A3 L = A3                                        07189000 0
15F7  0100 0000 0000 00AC                COMP 16 = SAR; 16 = LIT                          07190000 0
15F8  4809 EC5C 103C 00F0                A3 OR B = A3             % A3 = (R(A))/(R(A))    07191000 0
15F9  4809 C000 CB00 C0F0                A2 = B                   % "M" INTO B            07192000 0
15FA  4809 2C5E 2000 C0F0                LIT - B = A2             % 16 COMPLEMENT OF SHIFT AMOUNT        07193000 0
15FB  4809 C000 000C 80F0                A2 = SAR                                         07194000 0
15FC  4809 E0C1 9030 C0F0                A3 C = A3                % PERFORM SHIFT         07195000 0
15FD  4809 E001 1030 00FC                A3 L = A3                                        07196000 0
15FE  0C0C 0CC0 CC3C CC20                COMP 16 = SAR                                    07197000 0
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15FF  4809 E000 8B30 00F0             A3 R = MIR, B                                                       07198000 D
1600  2F5C 0000 0C40 C060             EOUTPUT - 1 = CPCR      % WRITE OUT NEW (R(A))                      07199000 D
1601  2C00 0000 C000 C060             SETCCA - 1 = CPCR       % SET THE CONDITION BITS                    07200000 D
1602  56EC 0000 C000 0040             OPCODE - 1 = MPCR                                                   07201000 D
                                                              %                                           07202000 D
                                                              %                                           07203000 D
                            OP612:                            % RL TYPE ALG LEFT DOUBLE SHIFT             07204000 D
                                                              % (R(A),R(A+1)), M (0-3)                    07205000 D
                                                              % ZERO FILL, SET CC, AND SET OVERFLOW       07206000 D
1603  4809 0C40 8B0C 00F0             B R = B                                                             07207000 D
1604  80F0 0000 C000 0080             4 = SAR; 15 = LIT                                                   07208000 D
1605  4809 E156 200C 00F0             A3 AND LIT = A2         % "M" INTO A2                               07209000 D
1606  4809 2C56 0B00 00F0             LIT AND B = B           % ISOLATE "A" FIELD                         07210000 D
1607  51C0 0000 0000 0060             REGSTACK - 1 = CPCR                                                 07211000 D
1608  4809 0F41 C020 00F0             BMAR L = BR1            % TEMP STORAGE OF R(A)                      07212000 D
1609  000C 0000 000C 0030             COMP 8 = SAR                                                        07213000 D
160A  2F3C 0000 0C0C C060             EINPUT - 1 = CPCR       % (R(A)) INTO B                             07214000 D
160B  4809 CC41 100C C0FC             B L = A3                                                            07215000 D
160C  0010 0C00 0C00 C0AC             COMP 16 = SAR ; 1 = LIT                                             07216000 D
160D  4809 2F5C 001C 00F0             LIT OR BMAR = MAR2      % R(A+1)                                    07217000 D
160E  2F30 C000 0000 0060             EINPUT - 1 = CPCR       % (R(A+1)) INTO B                           07218000 D
160F  48C9 EC5C 1000 00F0             A3 OR B = A3            % A3 =(R(A))/(R(A+1))                       07219000 D
1610  4809 C002 200C 00F0             NOT A2 = A2                                                         07220000 D
1611  4809 C0C0 0000 80F0             A2 + 1 = SAR                                                        07221000 D
1612  4809 EC00 8B0C 00F0             A3 R = B                                                            07222000 D
1613  4809 0C42 C000 00F0             NOT B                                                               07223000 D
1614  63C9 0000 0C2C 00F0             IF NOT ABT THEN SET LC1                                             07224000 D
1615  5020 0000 0000 C06C             OVBIT - 1 = CPCR        % SET THE OVERFLOW BIT                      07225000 D
1616  4809 C0C0 0C00 80F0             A2 + 1 = SAR                                                        07226000 D
1617  49C9 EDC1 1B0C 00F0             A3 L = A3, B; SET LC1                                               07227000 D
1618  2000 0000 0C00 C060             SETCCA - 1 = CPCR       % SET THE CONDITION BITS                    07228000 D
1619  4809 EC01 0B00 00F0             A3 L = B                                                            07229000 D
161A  000C C000 C000 0020             COMP 16 = SAR                                                       07230000 D
161B  48C9 0C40 8C30 00FC             B R = MIR                                                           07231000 D
161C  2F5C 0000 0000 C060             EOUTPUT - 1 = CPCR      % OUTPUT (R(A+1))                           07232000 D
161D  4809 C0C0 000C 20F0             ASR                     % REFERENCE BR1                             07233000 D
161E  48C9 0F40 801C C0F0             BMAR R = MAR2           % R(A)                                      07234000 D
161F  000C 00C0 CC00 C010             8 = SAR                                                             07235000 D
1620  48C9 E0C0 8C30 00FC             A3 R = MIR                                                          07236000 D
1621  000C 0000 0000 C020             16 = SAR                                                            07237000 D
1622  2F5C 0000 0000 0060             EOUTPUT - 1 = CPCR      % OUTPUT (R(A))                             07238000 D
1623  56EC 0000 C000 004C             OPCODE - 1 = MPCR                                                   07239000 D
                                                              %                                           07240000 D
                                                              %                                           07241000 D
                            OP613:                            % RL TYPE CIRCULAR LEFT DOUBLE SHIFT        07242000 D
                                                              % (R(A),R(A+1)), M (0-3) AND SET CC         07243000 D
1624  48C9 2C56 200C CCF0             LIT AND B = A2          % "M" INTO A2                               07244000 D
1625  80FC C000 0C00 C08C             15 = LIT ; 4 = SAR                                                  07245000 D
1626  4809 0C40 8B0C 00F0             B R = B                                                             07246000 D
1627  4809 2C56 0B0C 00F0             LIT AND B = B           % "A" INTO B                                07247000 D
1628  51C0 0000 0000 0060             REGSTACK - 1 = CPCR                                                 07248000 D
1629  4809 0F41 C020 00F0             BMAR L = BR1            % TEMP STORAGE                              07249000 D
162A  000C 0000 0000 C030             COMP 8 = SAR                                                        07250000 D
162B  2F30 0000 000C 0060             EINPUT - 1 = CPCR       % (R(A)) INTO B                             07251000 D
162C  4809 CC41 1C00 00FC             B L = A3                                                            07252000 D
162D  0010 0000 C000 00A0             COMP 16 = SAR; 1 = LIT                                              07253000 D
162E  48C9 2F5C 001C C0FC             LIT OR BMAR = MAR2      % R(A+1)                                    07254000 D
162F  2F3C 0000 0000 006C             EINPUT - 1 = CPCR       % (R(A+1)) INTO B                           07255000 D
1630  4809 EC5C 1000 00F0             A3 OR B = A3            % A3 = (R(A))/(R(A+1))                      07256000 D
1631  4809 C002 200C 0CF0             NOT A2 = A2                                                         07257000 D
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1632 4809 C0C0 0C0C 80F0            A2 + 1 = SAR
1633 49C9 E001 9B0C C0F0            A3 C = A3,D; SET LC1   % CIRCULAR SHIFT
1634 20D0 0000 0C0C 006C            SETCCA - 1 = CPCR      % SET THE CONDITION BITS
1635 4809 E001 0B30 00F0            A3 L = B
1636 000C 0000 0000 C020            COMP 16 = SAR
1637 4809 0C40 8C30 C0F0            B R = MIR
1638 2F50 00C0 0C00 006C            EOUTPUT - 1 = CPCR     % OUTPUT (R(A+1))
1639 4809 0000 0CD0 20F0            ASR                    % REF BR1
163A 4809 CF43 801C C0F0            BMAR R = MAR2
163B 000C C0C0 0C30 C010            B = SAR
163C 4809 E0C0 803C 00FC            A3 R = MIR             % (R(A)) INTO MIR
163D 0000 00C0 C030 0020            16 = SAR
163E 2F5C C0C0 0C00 CC6C            EOUTPUT - 1 = CPCR     % OUTPUT SHIFTED (R(A))
163F 56E0 0000 0C30 004C            OPCODE - 1 = MPCR
                                                           %
                                                           %
1640 5F9C C0C0 0030 0060  OPCODE62:  XFCODE - 1 = CPCR     % "F" INTO A2
1641 4809 C643 0C3C C0F0            A2 + AMPCR = AMPCR
1642 1FDC 00C0 C030 00C0            OP62F - 1 = AMPCR
1643 4809 0000 0C3C C0FC            STEP
1644 4824 0000 0C30 00F0            EXEC
                                                           %
1645 1FEC 0000 003C C040  OP62F:     OP620 - 1 = MPCR
1646 1FFC C003 0C30 004C            OP621 - 1 = MPCR
1647 200C 00C0 000C 004C            OP622 - 1 = MPCR
1648 2010 00C0 000C 004C            OP623 - 1 = MPCR
                                                           %
                                                           %
                          OP620:                           % TYPE RL SUBTRACT, (R(A))-M=R(A)
                                                           % SET CC, CARRY AND OV BITS
1649 22BC CCC0 0C0C C060            CONTENTSRA - 1 = CPCR  % (R(A)) INTO B
164A 4809 CC41 200C 00FC            B L = A2               % (R(A)) INTO MS WORD OF A2
164B 00F0 00C0 000C C0A0            COMP 16 = SAR; 15 = LIT
164C 4609 E156 0B30 C0F0            A3 AND LIT = B         % "M" INTO B
164D 4809 0C41 0B30 C0F0            B L = B                % "M" INTO MS WORD OF B
164E 4649 CC5E C030 00FC            A2 - B = MIR; SET LC2
164F 7BC9 0000 C03C C0F0            IF AOV THEN SET LC1
1650 1E70 C0C0 0C30 006C            CARRY - 1 = CPCR
1651 4F1C 0CC3 CC30 C060            CHECKOV - 1 = CPCR
1652 4809 00C0 0D3C 00FC            BMI
1653 4809 0C40 8B3C C0F0            B R = MIR,B            % NEW (R(A)) INTO LS WORD OF MIR,B
1654 00C0 C0C0 003C C020            16 = SAR
1655 20DC C0C0 C03C 0060            SETCCA - 1 = CPCR      % SET THE CONDITION BITS
1656 2F5C CCC0 003C 0060            EOUTPUT - 1 = CPCR     % (R(A))-M INTO R(A)
1657 56EC 0000 003C CC4C            OPCODE - 1 = MPCR
                                                           %
                                                           %
                          OP621:                           % TYPE RL LITERAL SUBTRACT DOUBLE
                                                           %(R(A),R(A+1)) - M = R(A),R(A+1)
                                                           % SET CC, CARRY AND OV BITS
1658 4809 2C56 0C30 00FC            LIT AND B = MIR        % "M" INTO MIR
1659 8CFC 0CC0 0C30 0080            15 = LIT; 4 = SAR
165A 4809 0C40 8B3C C0FC            B R = B                % SHIFT "A" TO LS 4 BITS
165B 4809 2C55 0B3C C0F0            LIT AND B = D          % ISOLATE "A" FIELD
165C 51CC C003 0C3C C060            REGSTACK - 1 = CFCR
165D 4809 0F41 0020 C0F0            BMAR L = BR1           % TEMP STORAGE
165E 000C C0C0 0C00 0030            COMP 8 = SAR
165F 2F30 C0C0 CC0C 0060            FINPUT - 1 = CPCR      % (R(A)) INTO B
1660 4809 0C41 2C00 C0F0            B L = A2               % (R(A)) INTO MS WORD OF A2
1661 001C C0C3 0C30 00A0            COMP 16 = SAR ; 1 = LIT
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1662  4809 2F5C 0C1C 00F0          LIT OR BMAR = MAR2        % R(A+1)
1663  2F3C 0000 0000 0060          EINPUT - 1 = CPCR         % (R(A+1)) INTO B
1664  4809 CC5C 2D0C 00F0          A2 OR B = A2, BMI         % A2 = (R(A))/(R(A+1))
1665  4849 CC5E 009C 00F0          A2 - 9 = MIR; SET LC2
1666  7BC9 0000 0000 00F0          IF AOV THEN SET LC1
1667  1E7C 0000 000C 0060          CARRY - 1 = CPCR
1668  4F1C 0000 0000 0060          CHECKOV - 1 = CPCR
1669  49C9 0000 0000 00F0          BMI; SET LC1
166A  2000 0000 000C 006C          SETCCA - 1 = CPCR
166B  48C9 0000 000C 00F0          BMI
166C  4809 0C41 2000 00F0          B L = A2
166D  0000 0000 0C0C 0020          COMP 16 = SAR
166E  4809 CC40 8B0C 00F0          B R = B
166F  4809 C0C0 8C3C 00F0          A2 R = MIR                % NEW (R(A+1))
1670  2F50 0000 0C0C 0060          EOUTPUT - 1 = CPCR
1671  4809 0000 C03C 20F0          ASR                       % PEF BR1
1672  48C9 0F40 801C 00F0          BMAR R = MAR2
1673  0000 0000 0C00 C010          B = SAR
1674  4809 CC40 003C 00F0          B = MIR                   % NEW (R(A))
1675  2F50 0000 0000 C060          EOUTPUT - 1 = CPCR
1676  66EC 0000 0000 C040          OPCODE - 1 = MPCR
                                                             %
                                                             %
                         OP622:                              % TYPE RL LITERAL ADD, (R(A))+M -> R(A)
                                                             % SET CC, CARRY AND OV BITS
1677  22BC 0C00 0000 0060          CONTENTSRA - 1 = CPCR     % (R(A)) INTO B
1678  4809 CC41 2030 00F0          B L = A2
1679  0CF0 C000 0090 00A0          COMP 16 = SAR; 15 = LIT
167A  4809 E155 0B3C 00F0          A3 AND LIT = B            % ISOLATE "M" FIELD
167B  4809 0C41 0B0C 00F0          B L = B                   % "M" INTO MS WORD OF B
167C  4809 CC40 0090 C0F0          A2 + B = MIR              % PERFORM ADDITION
167D  7BC9 00C0 000C 00F0          IF AOV THEN SET LC1
167E  1E7C 0000 000C C060          CARRY - 1 = CPCR
167F  4F10 0000 000C 0060          CHECKOV - 1 = CPCR
1680  4809 00C0 0030 00F0          BMI
1681  4809 0C40 8B3C 00FC          B R = MIR,B
1682  0C00 00C0 0C0C 002C          16 = SAR
1683  2000 00C0 0C30 006C          SETCCA - 1 = CPCR         % SET THE CONDITION BITS
1684  2F5C C000 000C C060          EOUTPUT - 1 = CPCR        % (R(A))+M INTO R(A)
1685  66EC 0000 C00C 004C          OPCODE - 1 = MPCR
                                                             %
                                                             %
                         OP623:                              % TYPE RL LITERAL ADD DOUBLE
                                                             % (R(A),R(A+1)) + M INTO R(A),R(A+1)
                                                             % SET CC, CARRY, AND OV BITS
1686  4809 0C40 8B30 00F0          B R = B
1687  9CFC 00C0 0C00 0080          4 = SAR; 15 = LIT
1688  4809 E156 003C 00FC          A3 AND LIT = MIR          % "M" INTO MIR
1689  4809 2C56 0B30 0CF0          LIT AND B = B             % ISOLATE "A" FIELD
168A  51C0 0000 0C00 C060          REGSTACK - 1 = CPCR       % R(A) INTO MAR2
168B  4809 CF01 0C20 00FC          BMAR L = BR1              % TEMP STORAGE
168C  000C C0C0 0C30 C03C          COMP 8 = SAR
168D  2F3C C0C0 0C0C C06C          EINPUT - 1 = CPCR         % (R(A)) INTO B
168E  4809 CC41 2C3C C0F0          B L = A2                  % (R(A)) INTO MS WORD OF A2
168F  001C C000 000C C0A0          COMP 16 = SAR ; 1 = LIT
1690  4809 2F5C CC1C C0FC          LIT OR BMAR = MAR2        % R(A+1)
1691  2F3C C0C0 0C0C 0060          EINPUT - 1 = CPCR         % (R(A+1)) INTO B
1692  4809 CC5C 2D00 C0F0          A2 OR B = A2, BMI         % A2 = (R(A))/(R(A+1))
1693  4809 CC40 0C30 C0F0          A2 + B = MIR
1694  7BC9 0000 0C0C 00F0          IF AOV THEN SET LC1
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1695  1E70 0000 0000 0060               CARRY - 1 = CPCR
1696  4F10 0000 0000 0060               CHECKOV - 1 = CPCR
1697  49C9 C000 0000 00F0               BMI; SET LC1
1698  200C 0000 0000 C060               SETCCA - 1 = CPCR
1699  4809 C000 000C C0F0               BMI
169A  4809 0C41 2000 C0F0               B L = A2
169B  000C 0000 0000 C020               COMP 16 = SAR
169C  4809 CC40 8000 00F0               B R = B
169D  4809 CC00 8C30 00F0               A2 R = MIR              % NEW (R(A+1))
169E  2F5C 0000 0C00 C060               EOUTPUT - 1 = CPCR
169F  4809 0000 0C3C 20F0               ASR                     % REF ER1
16A0  4809 0F43 8010 00F0               BMAR R = MAR2           % R(A)
16A1  00C0 C000 C000 0010               B = SAR
16A2  4809 0C40 0090 00F0               B = MIR                 % NEW (R(A))
16A3  2F5C CCC3 000C C060               EOUTPUT - 1 = CPCR
16A4  66EC C003 0000 C040               OPCODE - 1 = MPCR
                                                                %
                                                                %
16A5  5F90 C000 000C C060   OPCODE63:   XFCODE - 1 = CFCR       % "F" INTO A2
16A6  4809 C640 C040 00F0               A2 + AMPCR = AMPCR
16A7  202C 0000 0C0C 00C0               OP63F - 1 = AMPCR
16A8  4809 0000 000C C0FC               STEP
16A9  4824 00C0 0000 00F0               EXEC
                                                                %
16AA  2030 0000 0000 004C   OP63F:      OP630 - 1 = MPCR
16AB  2040 0000 000C C040               OP631 - 1 = MPCR
16AC  205C 0000 0000 0040               OP632 - 1 = MPCR
16AD  2060 0000 0000 C040               OP633 - 1 = MPCR
                                                                %
                                                                %
                    OP630:                                      % TYPE RL LITERAL LOAD, M INTO R(A)
                                                                % SET C", CARRY AND OV BITS
16AE  4809 2C56 0B0C C0F0               LIT AND B = B           % ISOLATE "M"
16AF  80FC 0000 0000 C080               15 = LIT; 4 = SAR
16B0  4809 0C40 003C 00F0               B = MIR
16B1  4809 E000 8B0C C0F0               A3 R = B
16B2  4809 2C56 0E30 00FC               LIT AND B = B           % ISOLATE "A"
16B3  51CC 0000 0C0C 0060               REGSTACK - 1 = CPCR
16B4  2F50 C000 003C C06C               EOUTPUT - 1 = CPCR      % WRITE "M" INTO R(A)
16B5  21B0 0000 0000 C060               SETOO - 1 = CPCR
16B6  66E0 00C0 0C00 C040               OPCODE - 1 = MPCR
                                                                %
                                                                %
                    OP631:                                      % FL TYPE LITERAL COMPARE, (R(A)):M
                                                                % SET CC, CARRY, AND OV BITS
16B7  48C9 2C56 0030 00FC               LIT AND B = MIR         % "M" INTO MIR
16B8  00FC C000 0000 C0EC               15 = LIT
16B9  4809 E000 0B0C C0F0               A3 = B
16BA  22BC C0C3 0C0C C060               CONTENTSRA - 1 = CPCR   % (R(A)) INTO E
16BB  4809 0C41 2030 C0FC               B L = A2, BMI           % (R(A)) INTO MS WORD OF A2
16BC  000C C000 0000 0020               COMP 16 = SAR
16BD  4809 0C41 9E00 00FC               B L = B                 % "M" INTO MS WORD OF B
16BE  20C0 0000 CC30 0060               SETCC - 1 = CPCR        % SET THE CONDITION BITS
16BF  4849 CC5E 0030 C0F0               A2 - B = MIR; SET LC2
16C0  7BC9 C0C0 000C C0F0               IF AOV THEN SET LC1
16C1  1E70 0003 0000 C060               CARRY - 1 = CPCR
16C2  4F1C 0003 000C C060               CHECKOV - 1 = CPCR
16C3  66EC C000 0000 004C               OPCODE - 1 = MPCR
                                                                %
                                                                %
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                             OP632:                  % TYPE RL LITERAL MULTIPLY                             07438000 0
                                                     % R(A+1) X M = (R(A),R(A+1)), SET CC                   07439000 0
16C4  2809 0C40 8B30 C0FC          B R = B; IF LC1                                                          07440000 0
16C5  8CF0 00C0 CC30 0080          4 = SAR; 15 = LII                                                        07441000 0
16C6  4809 2C56 C000 C0F0          LII AND B = B         % ISOLATE "A"                                      07442000 0
16C7  51C0 00C0 0000 C060          REGSTACK - 1 = CPCR                                                      07443000 0
16C8  4809 CF41 CC20 00FC          BMAR L = BR1          % TEMP STORAGE                                     07444000 0
16C9  0000 0000 0000 0030          COMP 8 = SAR                                                             07445000 0
16CA  4809 0F46 0B30 C0FC          BMAR + 1 = B          % R(A+1)                                           07446000 0
16CB  51C0 00C0 0030 C060          REGSTACK - 1 = CPCR   % R(A+1) INTO MAR2                                 07447000 0
16CC  2F30 00C0 0020 C060          EINPUT - 1 = CPCR     % (R(A+1)) INTO B                                  07448000 0
16CD  4809 E155 2000 00F0          A3 AND LIT = A2       % "M" INTO A2                                      07449000 0
16CE  C0FC 0000 0000 00E0          15 = LIT                                                                 07450000 0
16CF  4C60 0C00 000C C060          MULT - 1 = CPCR       % (R(A+1)) X M INTO A3                             07451000 0
16D0  4809 E000 CB30 00F0          A3 = B, MIR           % PRODUCT INTO B, MIR                              07452000 0
16D1  200C 00C0 C000 C060          SETCCA - 1 = CPCR     % SET THE CONDITION BITS                           07453000 0
16D2  4809 EC01 0B30 00F0          A3 L = B                                                                 07454000 0
16D3  00CC 0000 CC3C 0020          COMP 16 = SAR                                                            07455000 0
16D4  4809 CC40 8C30 CCF0          B R = MIR             % (R(A+1))                                         07456000 0
16D5  2F50 C0C0 CC00 0C60          EOUTPUT - 1 = CPCR                                                       07457000 0
16D6  4809 0C00 0C00 20F0          ASR                   % REF BR1                                          07458000 0
16D7  4809 0F43 801C 00F0          BMAR R = MAR2         % R(A)                                             07459000 0
16D8  0000 00C0 0C00 0010          8 = SAR                                                                  07460000 0
16D9  4809 E000 8030 00F0          A3 R = MIR            % (R(A))                                           07461000 0
16DA  0000 0003 0030 0020          16 = SAR                                                                 07462000 0
16DB  2F5C C0C0 000C 006C          EOUTPUT - 1 = CPCR                                                       07463000 0
16DC  66E0 0003 0000 C040          OPCODE - 1 = MPCR                                                        07464000 0
                                                     %                                                      07465000 0
                                                     %                                                      07466000 0
                             OP633:                  % TYPE RL LITERAL DIVIDE                               07467000 0
                                                     % (R(A),R(A+1))/M = R(A+1), REMAINDER                  07468000 0
                                                     % INTO R(A), SET CC AND OV                             07469000 0
16DD  4809 2C55 0B00 00F0          LIT AND 0 = B         % ISOLATE "M"                                      07470000 0
16DE  00FC C0C0 0C0C 00AC          15 = LIT; COMP 16 = SAR                                                  07471000 0
16DF  48C9 0C41 0030 00F0          B L = MIR             % LEFT JUSTIFY DIVISOR                             07472000 0
16E0  4809 E000 8B00 00FC          A3 R = B                                                                 07473000 0
16E1  300C C000 0000 00C0          4 = SAR                                                                  07474000 0
16E2  4809 2C56 CB00 C0F0          LIT AND 0 = B         % ISOLATE "A"                                      07475000 0
16E3  51C0 00C0 0000 C06C          REGSTACK - 1 = CPCR   % R(A) INTO MAR2                                   07476000 0
16E4  4809 0F41 0C20 00F0          BMAR L = BR1          % STORE R(A)                                       07477000 0
16E5  0000 00C0 000C 0030          COMP 8 = SAR                                                             07478000 0
16E6  2F3C 00C0 0000 006C          EINPUT - 1 = CPCR     % (R(A)) INTO B                                    07479000 0
16E7  4809 CC41 2020 00F0          B L = A2                                                                 07480000 0
16E8  000C 00C0 0000 0C2C          COMP 16 = SAR                                                            07481000 0
16E9  4809 0F46 C000 C0F0          BMAR + 1 = B          % R(A+1)                                           07482000 0
16EA  51CC 00C0 000C 0060          REGSTACK - 1 = CPCR   % R(A+1) INTO MAR2                                 07483000 0
16EB  2F30 C000 0000 006C          EINPUT - 1 = CPCR     % (R(A+1)) INTO B                                  07484000 0
16EC  49C9 CC5C 2030 00F0          A2 OR B = A2,BMI; SET LC1  % A2 = (R(A))/(R(A+1))                       07485000 0
16ED  2400 0003 0C00 0060          DIV - 1 = CPCR        % (R(A),R(A+1))/M                                  07486000 0
16EE  4809 0000 003C 20F0          ASR                   % REF BR1                                          07487000 0
16EF  4809 0F43 8C1C 00F0          BMAR R = MAR2         % R(A)                                             07488000 0
16F0  0000 0003 0030 0010          8 = SAR                                                                  07489000 0
16F1  4809 C000 0030 00FC          A2 = MIR              % REMAINDER                                        07490000 0
16F2  2F50 C000 0000 0060          EOUTPUT - 1 = CPCR                                                       07491000 0
16F3  4809 EC00 0B30 00FC          A3 = B, MIR           % QUOTIENT INTO B, MIR                             07492000 0
16F4  200C 0000 0000 C060          SETCCA - 1 = CPCR     % SET THE CONDITION CODE                           07493000 0
16F5  4809 0F46 0B30 00F0          BMAR + 1 = B          % R(A+1)                                           07494000 0
16F6  51C0 0C00 0030 C060          REGSTACK - 1 = CPCR   % R(A+1) INTO MAR2                                 07495000 0
16F7  2F50 C000 C030 C06C          EOUTPUT - 1 = CPCR    % QUOTIENT INTO R(A+1)                             07496000 0
16F8  5050 0C00 C000 C06C          CLEAROV - 1 = CPCR    % SET OV BIT                                       07497000 0
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16F9  66EC 00C0 C000 0040            OPCODE - 1 = MPCR                                     07498000 D
                                                          *                                07499000 D
                                                          *                                07500000 D
16FA  5F9C 00C0 C000 0060  OPCODE64:  XFCODE - 1 = CPCR   * "F" INTO A2                    07501000 D
16FB  4809 C640 004C C0F0            A2 + AMPCR = AMPCR                                    07502000 D
16FC  2C70 0000 C000 00C0            OP64F - 1 = AMPCR                                     07503000 D
16FD  4809 0000 0000 00F0            STEP                                                  07504000 D
16FE  4824 00C0 0C00 C0F0            EXEC                                                  07505000 D
                                                          *                                07506000 D
16FF  300C 0000 000C 0040  OP64F:    FAULT - 1 = MPCR                                      07507000 D
1700  3000 00C0 000C 0040            FAULT - 1 = MPCR                                      07508000 D
1701  300C 00C0 0000 C040            FAULT - 1 = MPCR                                      07509000 D
1702  2080 0000 000C C040            OP643 - 1 = MPCR                                      07510000 D
                                                          *                                07511000 D
                                                          *                                07512000 D
                           OP643:                         * RX TYPE BYTE SUBTRACT          07513000 D
                                                          * (R(A)) - (Y) BYTE INTO R(A)    07514000 D
                                                          * SET CC, CARRY, AND OV BITS     07515000 D
1703  4849 C000 C0C0 C0F0            SET LC2              * BYTE OPERATION FLAG FOR RXMFIELD  07516000 D
1704  570C 00C0 000C C060            RXMFIELD - 1 = CPCR  * Y INTO B                       07517000 D
1705  4809 0C41 0C10 C0F0            B L = BR2                                             07518000 D
1706  000C 0000 0C00 0030            COMP 8 = SAR                                          07519000 D
1707  60E0 0000 0C00 C060            EMULIN - 1 = CPCR    * (Y) INTO B                     07520000 D
1708  4809 0C41 003C 00FC            B L = MIR                                             07521000 D
1709  000C C0C0 C000 0020            COMP 16 = SAR                                         07522000 D
170A  4809 E0C0 0B0C C0FC            A3 = B                                                07523000 D
170B  226C 0000 C000 006C            CONTENTSRA - 1 = CPCR * (R(A)) INTO B                 07524000 D
170C  4809 CC41 2000 00FC            B L = A2,BMI          * (R(A)) INTO MS WORD OF A2     07525000 D
170D  000C C0C0 0C00 0C20            COMP 16 = SAR                                         07526000 D
170E  380B C0C0 0C00 00F0            IF LC2 THEN STEP ELSE SKIP                            07527000 D
170F  209C 000C 0C0C C04C            LS643 - 1 = MPCR                                      07528000 D
1710  4809 0C40 880C 00F0            B R = B              * GET MS BYTE OF (Y)             07529000 D
1711  000C 0000 C000 C030            24 = SAR                                              07530000 D
1712  4809 CC41 0B00 00F0            B L = B                                               07531000 D
1713  000C C000 000C C020            COMP 16 = SAR                                         07532000 D
1714  4849 CC5E 0C80 00F0  C643:     A2 - B = MIR; SET LC2                                 07533000 D
1715  7BC9 0000 0C0C 00F0            IF AOV THEN SET LC1                                   07534000 D
1716  1E70 C000 C000 C060            CARRY - 1 = CPCR                                      07535000 D
1717  4F1C 00C0 CC0C 0060            CHECKOV - 1 = CPCR                                    07536000 D
1718  4809 00C0 0D00 0CF0            BMI                                                   07537000 D
1719  48C9 0C40 8B3C 00F0            B R = B, MIR                                          07538000 D
171A  00CC 0C00 0C0C 0020            16 = SAR                                              07539000 D
171B  2F5C 0000 0C0C C060            EOUTPUT - 1 = CPCR   * WRITE NEW (R(A))               07540000 D
171C  200C 00C0 0000 C060            SETCCA - 1 = CPCR                                     07541000 D
171D  66EC 00C0 0C00 0040            OPCODE - 1 = MPCR                                     07542000 D
171E  4809 0C41 0BD0 40F0  LS643:    B L = B, CSAR                                         07543000 D
171F  0000 C000 0000 CC30            COMP 8 = SAR                                          07544000 D
1720  4809 0C40 8P00 C0FC            B R = B              * LS BYTE ISOLATED INTO B        07545000 D
1721  7130 00C0 C00C 005C            C643 - 1  = MPCR                                      07546000 D
                                                          *                                07547000 D
                                                          *                                07548000 D
1722  5F9C 00C0 003C 0060  OPCODE65:  XFCODE - 1 = CPCR   * "F" INTO A2                    07549000 D
1723  4809 C640 0C40 C0F0            A2 + AMPCR = AMPCR                                    07550000 D
1724  20AC CCC0 C000 C0C0            OP65F - 1 = AMPCR                                     07551000 D
1725  48C9 C000 CC0C C0FC            STEP                                                  07552000 D
1726  4824 0C00 0C0C C0F0            EXEC                                                  07553000 D
                                                          *                                07554000 D
1727  300C 0000 0000 C040  OP65F:    FAULT - 1 = MPCR                                      07555000 D
1728  300C 00C0 0C0C 0040            FAULT - 1 = MPCR                                      07556000 D
1729  300C 00C0 0C0C C040            FAULT - 1 = MPCR                                      07557000 D
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172A  2080 0000 0000 0040         OP653 - 1 = MPCR                                                  07558000 D
                                                      *                                             07559000 D
                                                      *                                             07560000 D
                        OP653:                        * TYPE RX BYTE ADD                            07561000 D
                                                      * (R(A)) + (Y) BYTE INTO R(A)                 07562000 D
                                                      * SET CC, CARRY, AND OV BITS                  07563000 D
172B  4849 0000 0000 00F0         SET LC2             * RXMFIELD BYTE FLAG                          07564000 D
172C  5700 0000 0000 0060         RXMFIELD - 1 = CPCR * Y INTO B                                    07565000 D
172D  4809 0C41 0010 00F0         B L = BR2                                                         07566000 D
172E  0000 0000 0000 0030         COMP 8 = SAR                                                      07567000 D
172F  50EC 0000 0000 C060         EMULIN - 1 = CPCR                                                 07568000 D
1730  4809 0C41 0090 C0F0         B L = MIR                                                         07569000 D
1731  0000 0000 0000 0020         COMP 16 = SAR                                                     07570000 D
1732  4809 E000 0B00 00F0         A3 = B                                                            07571000 D
1733  22B0 0000 0000 0060         CONTENTSRA - 1 = CPCR * (R(A)) INTO B                             07572000 D
1734  4809 0C41 2000 C0F0         B L = A2, BMI                                                     07573000 D
1735  0000 0000 0000 0020         COMP 16 = SAR                                                     07574000 D
1736  380B C000 0000 00F0         IF LC2 THEN STEP ELSE SKIP                                        07575000 D
1737  20CC 0000 0000 0040         LS653 - 1 = MPCR                                                  07576000 D
1738  4809 0C40 8B00 C0F0         B R = B             * ISOLATE MS BYTE OF (Y)                      07577000 D
1739  0000 0000 0030 0030         24 = SAR                                                          07578000 D
173A  4809 0C41 0B00 C0F0         B L = B                                                           07579000 D
173B  0000 0000 0000 0020         COMP 16 = SAR                                                     07580000 D
173C  4809 0C40 0030 C0F0 C653:   A2 + B = MIR        * PERFORM ADDITION                            07581000 D
173D  7BC9 0000 0000 00F0         IF ACV THEN SET LC1                                               07582000 D
173E  1E70 0000 0000 0060         CARRY - 1 = CPCR                                                  07583000 D
173F  4F10 0000 0000 0060         CHECKOV - 1 = CPCR                                                07584000 D
1740  4809 0000 C000 0CF0         BMI                                                               07585000 D
1741  4809 0C40 8B30 00F0         B R = B, MIR                                                      07586000 D
1742  0000 0000 0000 0020         16 = SAR                                                          07587000 D
1743  2F50 0000 0000 C060         EOUTPUT - 1 = CPCR                                                07588000 D
1744  20D0 0000 0000 C060         SETCCA - 1 = CPCR   * SET THE CONDITION BITS                      07589000 D
1745  56E0 0000 0000 C040         OPCODE - 1 = MPCR                                                 07590000 D
1746  4809 0C41 0B00 40F0 LS653:  B L = B, CSAR       * GET LS BYTE OF (Y)                          07591000 D
1747  0000 0000 0000 C030         COMP 8 = SAR                                                      07592000 D
1748  4809 0C40 8B00 00F0         B R = B                                                           07593000 D
1749  73B0 0000 0000 C050         C653 - 1 = MPCR                                                   07594000 D
                                                      *                                             07595000 D
                                                      *                                             07596000 D
174A  5F9C 0000 0000 0060 OPCODEF66: XFCODE - 1 = CPCR                                              07597000 D
174B  4809 C640 0040 C0F0         A2 + AMPCR = AMPCR                                                07598000 D
174C  20D0 0000 0000 C0C0         OP66F - 1 = AMPCR                                                 07599000 D
174D  4809 C000 0000 00F0         STEP                                                              07600000 D
174E  4824 C000 0000 00F0         EXEC                                                              07601000 D
                                                      *                                             07602000 D
174F  300C C000 0000 0040 OP66F:  FAULT - 1 = MPCR                                                  07603000 D
1750  300C C000 0000 0040         FAULT - 1 = MPCR                                                  07604000 D
1751  300C C000 0000 0040         FAULT - 1 = MPCR                                                  07605000 D
1752  20E0 0000 0000 C040         OP663 - 1 = MPCR                                                  07606000 D
                                                      *                                             07607000 D
                        OP663:                        * RX TYPE BYTE COMPARE, (R(A)):(Y) BYTE       07608000 D
                                                      * SET CC, CARRY, AND OV BITS                  07609000 D
1753  4849 0000 0000 00F0         SET LC2             * BYTE OPERATION FLAG FOR RXMFIELD            07610000 D
1754  5700 0000 0000 C060         RXMFIELD - 1 = CPCR * Y INTO B                                    07611000 D
1755  4809 0C41 0010 00F0         B L = BR2                                                         07612000 D
1756  0000 0000 0000 0030         COMP 8 = SAR                                                      07613000 D
1757  50EC 0000 0000 0060         EMULIN - 1 = CPCR   * (Y) INTO B                                  07614000 D
1758  4809 0C41 C030 CCFC         B L = MIR                                                         07615000 D
1759  0000 0000 0030 0020         COMP 16 = SAR                                                     07616000 D
175A  4809 E000 0B00 C0F0         A3 = B                                                            07617000 D
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175B  2280 0C00 0000 0060            CONTENTSRA - 1 = CPCR                                          07618000 D
175C  4809 0C41 2030 00F0            B L = A2, BMI                                                  07619000 D
175D  0000 0000 0000 0020            COMP 16 = SAR                                                  07620000 D
175E  380B 0000 0000 00F0            IF LC2 THEN STEP ELSE SKIP                                     07621000 D
175F  2CFC C000 0000 0040            LS663 - 1 = MPCR         * GET LS BYTE OF (Y)                  07622000 D
1760  4809 0C40 8B0C CCF0            B R = B                                                        07623000 D
1761  0000 C000 0030 0030            24 = SAR                                                       07624000 D
1762  4809 0C41 1B0C 00F0            B L = B, A3              * MS (Y) BYTE INTO MSW OF B, A3       07625000 D
1763  0000 0003 0000 C020            COMP 16 = SAR                                                  07626000 D
1764  4849 CC5E 0030 C0F0   C663:    A2 - B = MIR; SET LC2                                          07627000 D
1765  7BC9 0000 0000 C0F0            IF ADV THEN SET LC1                                            07628000 D
1766  1E70 0003 0000 0060            CARRY - 1 = CPCR                                               07629000 D
1767  4F1C C000 0000 0060            CHECKOV - 1 = CPCR                                             07630000 D
1768  4809 E000 0B0C 00FC            A3 = B                   * RESTORE (Y) INTO B                  07631000 D
1769  2C00 0003 0030 0060            SETCC - 1 = CPCR         * SET THE CONDITION BITS              07632000 D
176A  66EC 0000 C030 0040            OPCODE - 1 = MPCR                                              07633000 D
176B  4809 0C41 0B30 40F0   LS663:   B L = B, CSAR                                                  07634000 D
176C  0000 0000 0000 C030            COMP 8 = SAR                                                   07635000 D
176D  4809 0C40 9B30 C0F0            B R = B, A3                                                    07636000 D
176E  7630 0000 0000 0050            C663 - 1 = MPCR                                                07637000 D
                                                              *                                     07638000 D
                                                              *                                     07639000 D
176F  5F90 0000 0030 C060   OPCODE67:  XFCODE - 1 = CFCR                                            07640000 D
1770  4809 C640 0C40 00FC            A2 + AMPCR = AMPCR                                             07641000 D
1771  2100 0003 0030 C0C0            OP67F - 1 = AMPCR                                              07642000 D
1772  4809 0000 0030 00F0            STEP                                                           07643000 D
1773  4824 00C0 0C30 C0F0            EXEC                                                           07644000 D
                                                              *                                     07645000 D
1774  4E5C 0000 0000 0040   OP67F:   NOTIMP - 1 = MPCR                                              07646000 D
1775  4E50 0000 0000 C040            NOTIMP - 1 = MPCR                                              07647000 D
1776  4E50 C000 0000 0040            NOTIMP - 1 = MPCR                                              07648000 D
1777  2110 0003 0030 C040            OP673 - 1 = MPCR                                               07649000 D
                                                              *                                     07650000 D
                                                              *                                     07651000 D
                            OP673:                            * TYPE RX BYTE COMPARE AND INDEX BY 1 07652000 D
                                                              * (R(A)):(Y) BYTE, (R(M))+1 INTO R(M) 07653000 D
                                                              * SET CC, CARRY, AND OV BIT           07654000 D
1778  4849 0000 0000 C0F0            SET LC2                  * BYTE OPERATION FLAG FOR RXMFIELD    07655000 D
1779  570C 0000 0C00 C060            RXMFIELD - 1 = CFCR      * Y INTO B                            07656000 D
177A  4809 0C41 0010 C0FC            B L = BR2                                                      07657000 D
177B  000C 0000 0000 0030            COMP 8 = SAR                                                   07658000 D
177C  60E0 0C00 0000 0060            EMULIN - 1 = CPCR        * (Y) INTO B                          07659000 D
177D  4809 0C41 0030 C0F0            B L = MIR                                                      07660000 D
177E  000C 0000 000C 0020            COMP 16 = SAR                                                  07661000 D
177F  4809 E003 0B00 00F0            A3 = B                                                         07662000 D
1780  2280 0000 0030 0060            CONTENTSRA - 1 = CPCR    * (R(A)) INTO B                       07663000 D
1781  4809 0C41 2030 C0F0            B L = A2, BMI            * (R(A)) INTO MS WORD OF A2           07664000 D
1782  000C 0003 0C00 002C            COMP 16 = SAR                                                  07665000 D
1783  38CB C000 0030 C0F0            IF LC2 THEN STEP ELSE SKIP                                     07666000 D
1784  212C 0003 0030 004C            LS673 - 1 = MPCR                                               07667000 D
1785  4809 CC40 9B00 00F0            B R = B                                                        07668000 D
1786  0000 0000 0C00 0030            24 = SAR                                                       07669000 D
1787  4809 0C41 1B0C 00F0            B L = B, A3              * MS  (Y) BYTE INTO MS WORD OF B      07670000 D
1788  0000 0003 C000 C02C            COMP 16 = SAR                                                  07671000 D
1789  4849 CC5E C030 00F0   C673:    A2 - B = MIR; SET LC2                                          07672000 D
178A  7BC9 0000 0000 C0FC            IF ADV THEN SET LC1                                            07673000 D
178B  1E70 C000 0C0C 0060            CARRY - 1 = CPCR                                               07674000 D
178C  4F1C 0000 000C 0060            CHECKOV - 1 = CPCR                                             07675000 D
178D  4809 E000 0B30 C0F0            A3 = B                                                         07676000 D
178E  200C 0003 0C00 C060            SETCC - 1 = CPCR                                               07677000 D
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178F  2380 0000 0000 0060          CONTENTSRM - 1 = CPCR  % (R(P)) INTO B              07678000 0
1790  4809 0C46 0030 00F0          B + 1 = MIR            % (R(M)) + 1                  07679000 0
1791  2F50 0000 0000 0060          EOUTPUT - 1 = CPCR                                   07680000 0
1792  66E0 0000 0000 0040          OPCODE - 1 = MPCR                                    07681000 0
1793  4809 0C41 0B00 40F0   LS673: B L = B, CSAR          % ISOLATE LS EYTE OF (Y)      07682000 0
1794  0000 0000 0000 0030          COMP B = SAR                                         07683000 0
1795  4809 0C40 9B00 00F0          B R = B, A3                                          07684000 0
1796  7880 0000 0000 0050          C673 - 1 = MPCR                                      07685000 0
                                                          %                             07686000 0
                                                          %                             07687000 0
                            OPCODE70:                     % NOT IMPLEMENTED             07688000 0
1797  4E50 0000 0000 0040          NOTIMP - 1 = MPCR                                    07689000 0
                                                          %                             07690000 0
                            OPCODE71:                     % NOT IMPLEMENTED             07691000 0
1798  4E50 0000 0000 0040          NOTIMP - 1 = MPCR                                    07692000 0
                                                          %                             07693000 0
                            OPCODE72:                     % NOT IMPLEMENTED             07694000 0
1799  4E50 0000 0000 0040          NOTIMP - 1 = MPCR                                    07695000 0
                                                          %                             07696000 0
                            OPCODE73:                     % NOT IMPLEMENTED             07697000 0
179A  4E50 0000 0000 0040          NOTIMP - 1 = MPCR                                    07698000 0
                                                          %                             07699000 0
                            OPCODE74:                     % NOT IMPLEMENTED             07700000 0
179B  4E50 0000 0000 0040          NOTIMP - 1 = MPCR                                    07701000 0
                                                          %                             07702000 0
                            OPCODE75:                     % NOT IMPLEMENTED             07703000 0
179C  4E50 0000 0000 0040          NOTIMP - 1 = MPCR                                    07704000 0
                                                          %                             07705000 0
                            OPCODE76:                     % NOT IMPLEMENTED             07706000 0
179D  4E50 0000 0000 0040          NOTIMP - 1 = MPCR                                    07707000 0
                                                          %                             07708000 0
                            OPCODE77:                     % NOT ASSIGNED                07709000 0
179E  3000 0000 0000 0040          FAULT - 1 = MPCR                                     07710000 0
                                                          %                             07711000 0
179F  0000 0000 0000 0040          END                                                  07712000 0
1784  792C 0000 0000 0050   ?END
1777  777C 0000 0000 0050
1771  773C 0000 0000 0000
175F  76AC 0000 0000 0050
1752  7520 0000 0000 0050
174C  74EC 0000 0000 0000
1737  7450 0000 0000 0050
172A  72AC 0000 0000 0050
1724  7260 0000 0000 0000
170F  7100 0000 0000 0050
1702  702C 0000 0000 0050
16FC  6FE0 0000 0000 0000
16AD  5DCC 0000 0000 0050
16AC  6C30 0000 0000 0050
16AB  5B6C 0000 0000 0050
16AA  6ADC 0000 0000 0050
16A7  6A9C 0000 0000 0000
1648  6850 0000 0000 0050
1647  5760 0000 0000 0050
1646  6570 0000 0000 0050
1645  648C 0000 0000 0050
1642  644C 0000 0000 0000
15DA  623C 0000 0000 0050
1509  6020 0000 0000 0050
1508  5EEC 0000 0000 0050
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1507	5DA0	0000	0000	0050
1504	5D6C	0000	0000	0000
1573	5AAC	0000	0000	0050
1572	58FC	0000	0000	0050
1571	57BC	0000	0000	0050
1570	573C	0000	0000	0050
156D	56FC	0000	0000	0000
152D	552C	0000	0000	0050
152B	53E0	0000	0000	0050
152A	52DC	0000	0000	0050
1527	529C	0000	0000	0000
14F5	50FC	0000	0000	0050
14F3	506C	0000	0000	0050
14F2	4F5C	0000	0000	0050
14EF	4F1C	0000	0000	0000
14B2	4D4C	0000	0000	0050
14B1	4C50	0000	0000	0050
14B0	4BE0	0000	0000	0050
14AF	4B2C	0000	0000	0050
14AC	4AEC	0000	0000	0000
1470	495C	0000	0000	0050
146F	4820	0000	0000	0050
146E	47CC	0000	0000	0050
146D	470C	0000	0000	0050
146A	46C0	0000	0000	0000
1436	456C	0000	0000	0050
1435	4450	0000	0000	0050
1434	440C	0000	0000	0050
1433	436C	0000	0000	0050
1430	4320	0000	0000	0000
13FF	41FC	0000	0000	0050
13FE	40EC	0000	0000	0050
13FD	4090	0000	0000	0050
13FC	3FFC	0000	0000	0050
13F9	3FBC	0000	0000	0000
13B2	3E60	0000	0000	0050
13B1	3D0C	0000	0000	0050
13B0	3B2C	0000	0000	0050
13AC	3AEC	0000	0000	0000
1371	396C	0000	0000	0050
1370	38C0	0000	0000	0050
136E	371C	0000	0000	0050
136B	36D0	0000	0000	0000
132B	353C	0000	0000	0050
132A	33D0	0000	0000	0050
1329	338C	0000	0000	0050
1328	32BC	0000	0000	0050
1325	3270	0000	0000	0000
12FA	3180	0000	0000	0050
12F9	305C	0000	0000	0050
12F7	2FAC	0000	0000	0050
12F4	2F6C	0000	0000	0000
12F1	2F1C	0000	0000	0050
12EE	2F1C	0000	0000	0050
12E8	2F1C	0000	0000	0050
12E5	2F1C	0000	0000	0050
12E0	2F1C	0000	0000	0050
12DD	2F1C	0000	0000	0050
12DC	2F1C	0000	0000	0050
12D7	2F1C	0000	0000	0050

12D2	2F10	0000	0000	0050
12D0	2F10	0000	0000	0050
12C8	2F10	0000	0000	0050
12C4	2F10	0000	0000	0050
12C0	2E80	0000	0000	0050
12BF	2E00	0000	0000	0050
129F	2D00	0000	0000	0050
12B0	20C0	0000	0000	0050
12BA	2D70	0000	0000	0050
12B9	2D20	0000	0000	0050
12B0	2C00	0000	0000	0050
12B7	2C80	0000	0000	0050
12B6	2C40	0000	0000	0050
12B5	2C00	0000	0000	0050
12B2	2B40	0000	0000	0000
12A9	3210	0000	0000	0050
1291	2990	0000	0000	0050
1264	26D0	0000	0000	0050
1244	2880	0000	0000	0050
1243	2780	0000	0000	0050
1242	25B0	0000	0000	0050
1241	2440	0000	0000	0050
123E	2400	0000	0000	00D0
11EB	2280	0000	0000	0050
11EA	20E0	0000	0000	0050
11E9	1FB0	0000	0000	0050
11E8	1EB0	0000	0000	0050
11E5	1E70	0000	0000	00D0
117A	1C90	0000	0000	0050
1179	1A90	0000	0000	0050
1178	1900	0000	0000	0050
1177	17A0	0000	0000	0050
1174	1760	0000	0000	00D0
113C	1650	0000	0000	0050
113B	1520	0000	0000	0050
113A	1460	0000	0000	0050
1139	13C0	0000	0000	0050
1136	1380	0000	0000	00D0
10FE	1270	0000	0000	0050
10F0	1140	0000	0000	0050
10FC	1080	0000	0000	0050
10FB	0FE0	0000	0000	0050
10F8	0FA0	0000	0000	0000
10C0	0E90	0000	0000	0050
10BF	0D60	0000	0000	0050
10BE	0CA0	0000	0000	0050
10B0	0CD0	0000	0000	0050
10BA	0BC0	0000	0000	0000
1017	0920	0000	0000	0050
1016	0630	0000	0000	0050
1015	0300	0000	0000	0050
1014	0170	0000	0000	0050
1011	0130	0000	0000	0000
0F8C	FFC0	0000	0000	0040
0F8B	FCB0	0000	0000	0040
0F8A	FAA0	0000	0000	0040
0F89	F8C0	0000	0000	0040
0F86	F880	0000	0000	00C0
0F30	F680	0000	0000	0040
0F2E	F4B0	0000	0000	0040

0F2D	F300	0000	0000	0040
0F2A	F2C0	0000	0000	00C0
0FDE	F150	0000	0000	0040
0EDD	EFD0	C000	0000	0040
0EDC	EEC0	0000	0000	0040
0EDD	EDEC	C000	0000	C040
0ED8	EDA0	0000	000C	00C0
0E5E	EADC	0000	000C	004C
0E5C	E850	0000	0000	0040
0E5B	E5EC	0000	0000	004C
0E58	E5A0	C000	0000	0CC0
0E00	E410	0000	0000	0040
0DFF	E270	00C0	0CD0	C040
0DFE	E120	C0C0	C0DC	C040
0DFD	E00C	00C0	0C00	D040
0DFA	DFC0	C000	0C00	00C0
0D79	DCDC	0000	CC0C	C040
0D77	DA10	0000	000C	0040
0D76	D79C	C000	0C00	0040
0D73	D75C	00C0	0C0C	00C0
0D19	D5C0	0000	0000	0040
0D18	D42C	0000	0C0C	0040
0D17	D280	0000	0000	C040
0D16	D19C	0000	000C	0040
0D13	D15C	0000	C00C	C0C0
0CBF	D0AC	0000	0C00	C040
0CBE	CE30	0000	DCDC	C040
0CBD	CD00	0000	0C0C	0040
0CBC	CBFC	0000	0C0C	0040
0CB9	CBB0	C0C0	0000	00C0
0C32	C9D0	0000	CC00	CC40
0C31	C710	00C0	0CDC	C040
0C30	C560	0000	0CDC	0040
0C2F	C320	0000	000C	0040
0C2C	C2E0	0000	0C0C	00C0
0BD5	C1D0	00C0	0000	0040
0BD4	BF9C	0000	0C00	C04C
0BD3	BEBC	0CC0	0000	0040
0BD2	BD5C	CCC0	0000	C040
0BCF	BD10	00C0	C000	00C0
0BBC	BC6C	0000	000C	C060
0B97	BA30	CCC0	0C0C	0040
0B6F	B7B0	0CC0	C000	0040
0B64	BAA0	0000	0000	C040
0B63	B820	0000	0000	0040
0B61	B64C	0000	0000	0040
0B5E	B600	00C0	000C	C0C0
0AE9	B38C	00C0	0000	0040
0AE8	B0C0	C000	000C	0040
0AE6	AE90	0CC0	C0D0	0040
0AE3	AE5C	C0C0	000C	C0CC
0A72	ACA0	00C0	0000	C040
0A71	AA30	C000	0000	C040
0A70	A91C	C000	C00C	0040
0A6F	A72C	C000	C000	C040
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0A1E	A30C	C000	C0C0	C040
0A1D	A360	0000	0C00	C040
0A1C	A1F0	0000	C00C	0040

0A19	A1BC	C0C0	0000	00C0
CA0D	A120	00C0	0000	0040
0A05	A0D0	00C0	0000	0040
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C9DC	9E7C	0000	000C	0040
09DA	9DDC	C0C0	0C00	0040
C9D7	9D90	0C00	0C00	00C0
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0988	98B0	00C0	C00C	004C
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0909	90BC	00C0	0000	C040
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088E	8ECC	00C0	0C00	C040
088D	8DB0	0C00	0C00	0040
088C	9C8C	C0C0	0000	0040
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07FD	822C	0000	0000	0040
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C7EF	951C	0000	0C00	0040
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071E	720C	0000	0C0C	C0C0

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069E	3680	0000	0000	0050
069D	3220	0000	0000	0050
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048A	60E0	0000	0000	0060
047D	47B0	0000	0000	0040
0475	60EC	0000	0000	0060

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C467	51CC	00CD	0C00	C060
0464	46FC	C0C0	0000	C040
C462	51CC	000D	C000	C060
045F	47DC	C0CD	000C	CC40
045D	50EC	C0C0	CCD0	0060
C458	469C	0CC0	0C0C	C040
C457	464C	0CCD	CC0C	C040
0456	45F0	C0CD	0CCC	0C4C
0455	4580	C0CD	000C	C040
C452	454C	000D	CC0C	0CCC
044A	5DE0	000D	000C	C06C
0444	444C	0CCD	0C0C	CC40
C442	51CC	0C00	0000	C060
043E	4440	C0C0	CC0C	0040
043C	444C	C0C0	000C	0040
C43A	51CC	CCCD	0C0C	C060
C436	60EC	CCCD	0C0C	C060
C431	43EC	0CCD	0C0C	0040
C430	43CC	0CCD	C0CC	0040
042F	437C	00C0	000C	0040
C42E	4310	C000	0C0C	004C
042B	42D0	000D	CC0C	C0C0
C425	44CC	00CD	000C	0040
0424	4250	000D	0C0C	C04C
C41F	60E0	0CCD	CC00	006C
C416	416C	0C0D	000C	C040
0415	6330	0C0D	C000	0060
C410	416C	000D	0C00	004C
C406	6330	00CD	0000	C06C
C3F0	66E0	CC0D	CCD0	C04C
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03D5	66EC	CCCD	0000	C040
03C8	3F70	0CCD	C0CC	0060
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03BC	3DEC	CCC0	0C0C	C040
C3B9	3BBC	CCC0	CC00	C0C0
C3AC	66EC	C0CD	000C	C040
03A2	3F7C	0CC0	0C0C	C060
C38E	66EC	00CD	CCCC	0C40
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0375	399C	0000	CC0C	C040
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C348	61E0	0CC0	0C00	C060
C340	60EC	C0C0	C00C	006C
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02DC	5E5C	0000	0000	0060
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02CB	5E5C	0000	0000	0060
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025E	261C	0000	0000	0040
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0236	2F30	0000	0000	0060
0230	51CC	0000	0000	0060
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020D	216C	0000	0000	0040
020C	21F0	0000	0000	0040
0209	21F0	0000	0000	0040
0208	2160	0000	0000	0040
0205	2090	0000	0000	0040
0203	219C	0000	0000	0040
01FB	2F5C	0000	0000	0060
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01E9	1EFC	0000	0000	0040
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01DA	66E0	0000	0000	0040
01B5	1BA0	0000	0000	0040
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0161	27EC	0000	0000	0060
013C	144C	0000	0000	0060
0124	169C	0000	0000	0040
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00ED	0F7C	0000	0000	0040
00EC	0F2C	0000	0000	0040
00E9	0ED0	0000	0000	0040
00B5	0B70	0000	0000	0040
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006E	0790	0000	0000	0060

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006C   0830 0000 0000 0060
0066   0810 0000 0000 0060
005B   0970 0000 0000 0060
005A   0870 0000 0000 0060
0059   05B0 0000 0000 0040
0051   5CF0 0000 0000 0040
0050   0810 0000 0000 0060
0049   0510 0000 0000 0060
0046   05E0 0000 0000 0040
0042   0510 0000 0000 0060
0041   0460 0000 0000 0060
0036   0600 0000 0000 0040
0035   1540 0000 0000 0040
0032   10D0 0000 0000 0040
002F   1810 0000 0000 0040
002C   1BF0 0000 0000 0040
0029   1AA0 0000 0000 0040
0026   1620 0000 0000 0040
0023   1790 0000 0000 0040
0020   0360 0000 0000 0040
001D   0BF0 0000 0000 0040
001A   0480 0000 0000 0040
0014   0AB0 0000 0000 0040
0011   0DD0 0000 0000 0040
000A   0460 0000 0000 0060
0007   0600 0000 0000 0040
 0 ERRORS   7714 CARDS.  36055 TOKENS.     65156 RULES.      5275 SECONDS.
 0 WARNINGS.     272 DISK SECTORS.
```

BIBLIOGRAPHY

1. Air Force Avionics Lab, Wright-Patterson AFB, Ohio, AFAL-TR-74-180, A Stack Machine Emulation, Anderson, C. M., January 1975.

2. Agrawala, A. K. and Rausher, T. G., "Microprogramming: Perspective and Status," IEEE Trans, C23, p. 817-37, August 1974.

3. Burkhard, W. A., "Flexible Computer Architectures for Research and Development," Computer Conference, Fall 1976.

4. Burroughs Corporation Report 64116, Emulation Facility, by Advanced Design Organization, Paoli, Pa., 28 June 1971.

5. Burroughs Corporation Report TR70-2, The Interpreter, by R. L. Davis, 16 February 1970.

6. Burroughs Corporation Report TR70-8, Microprogramming Manual for the Interpreter Based Systems, by Advanced Design Organization, Paoli, Pa., November 1970.

7. Burroughs Corporation Report 66143, Algol Reference Manual for the Interpreter Based System, by Advanced Design Organization, Paoli, Pa., 15 June 1975.

8. Computer Sciences Corporation, A Cost-Effective Emulation Approach for U. S. Army Telecommunications, by J. W. Carroll, p. 1-13.

9. Naval Electronics Laboratory Center and M. I. T. Sloan School of Management, Facilities Orientation Report, Volume 1, A Survey of the Navy Tactical Computer Applications and Executives, by Professors S. E. Madnick and J. D. Detreville, October 1975.

10. Haggerty, J. M. and Hartling, J. M., Emulation of the AN/UYK-7 Tactical Data Computer on the Burroughs D-Machine, Masters Thesis, Naval Postgraduate School, Monterey, California, December 1976.

11. Husson, S. S., Microprogramming: Principles and Practices, Prentice-Hall, Inc., 1970.

12. Jones, L., "Instruction Sequencing in Microprogrammed Computers," Proceedings NCC, 44, p. 91-8, 1975.

13. Lichstein, H. A., "When Should You Emulate?," Datamation, 15, p. 205-10, November 1969.

14. Mallach, E. G., "Emulator Architecture," Computer, p. 24-32, August 1975.

15. Mercer, R. J., "Microprogramming," Journal for the Association of Computing Machines, 4, p. 157-71, April 1957.

16. Naval Material Command UNCLASSIFIED Letter MAT 09Y:JER Serial 130 to Naval Electronic Systems Command, Subject: Standard Shipboard Tactical Digital Processors and Program Languages, 29 May 1973.

17. Reigel, E. W., Faber, U., and Fisher, D. A., "The interpreter - A microprogramming building block system," Proceedings SJCC, 40, p. 705-23, 1972.

18. Rosin, R. F., "Contemporary Concepts of Microprogramming and Emulation," Computer Surveys, 1, p. 197-212, December 1969.

19. Saal, H. J. and Schuster, L. J., On Measuring Computer Systems by Microprogramming.

20. Sperry Rand, UNIVAC, Computer Set AN/UYK20 Technical Manual Operations and Maintenance with Parts List, N 00039-73-C-0432, September 1974.

21. Sperry Rand, UNIVAC, AN/UYK-20 Computer Repertiore of Instructions, Fall 1976.

22. Sperry Rand, UNIVAC, AN/UYK-20 Technical Description, November 1976.

23. Sperry Rand, UNIVAC, User's Handbook for AN/UYK-20(V) Computer Volume 3 (Change 4), NAVELEX 0967-LP-598-2030, April 1976.

24. Wilkes, M. B., "The Growth of Interest in Microprogramming: A Literature Survey," Computer Surveys, 1, p. 139-45, September 1969.

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